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2851 Tuesday, April 24, 1917, 10:00 a. m.

SAMUEL P. SADTLER resumed the stand for further

Direct examination.

By Mr. Scott:

Q. 134. Doctor, I think last night when the court adjourned you were giving a description of some kind of apparatus which you considered suitable for the Everson process, and in existence at the time the Everson invention was made. If you have not finished your answer, you may continue?

A. I cited two forms of apparatus, both taken from what might be called the dairy industry. I will next cite an apparatus which is already of record, namely, the extract from the treatise on the chemistry of the manufacture of soaps and candles, which was introduced by Dr. Byrne to illustrate a form of apparatus which was capable of entraining air by means of rapid agitation, (page 402 of the original Hyde record). We have an illustration there of the apparatus, and the description is the description of the class of soaps which are made by the aid of this apparatus. The heading is "Flotant Soaps." "Under this title are designated those soaps which, when in a state of paste, are batted or inflated with air, by which means its buoyancy becomes such that the soap floats in water."

2852 And after describing the material from which these soaps are made and the process of preparation, we have in the last part of the description: "When the mass is in perfect fusion it is agitated with a swirling fan, figures 54 and 55, until it froths and foams to the top of the vessel."

I consider this apparatus as a form of apparatus which is perfectly adapted to the process of aeration in connection with agitation. If a soap in the form of paste could be inflated with air by agitation, it is obvious that the relatively thinner, floating pulp, admixed with oil, could be aerated by the same form of apparatus, by the use of agitation, which is of course capable of being done by power as well as by hand. That is the third illustration of the apparatus adapted for aeration by means of agitation, which results in the production of an aerated froth under these conditions.

The fourth illustration in the prior art goes to another industry. In the purifying of linseed oil it is necessary to carry on a purifying step in which the crude oil is to be aerated with a view of causing the separation of impurities, and I find in a book which was published in 1882 (Die trocknenden Oele, by Louis Edgar Andes, published in Braunsweig, 1882), and which I have bound and which has been in my possession in my library since 1883, a description of the apparatus known as the "cataract" machine, and photographs have been made, illustrations have been made of the apparatus, that

is, a page showing the apparatus together with a title page to the book, and I will translate and put in English, therefore, the description. The description begins on the preceding page, on
2853 page 37, and is continued on page 38, where this figure is given, at the top of the page, where reference is made to the entraining of air. But I will read the whole description:

"The cataract machine built by the stock company for the manufacture of machines and the oil industry at Barell, in the Grand Duchy of Oldenberg appears specially adapted over all other machines of like character used for the rapid purification of oil, to displace them in use, and the same therefore deserves entrance into all varnish and lacquer establishments. Figure 6, on the following page shows a vertical section through the machine. The oil to be purified is filled into the iron cylindrical vessel up to a certain mark. On turning the rotating wheel F, the blades, F1, are moved in rapid rotation. The oil rises in consequence of the action of centrifugal force on the walls of the vessel and is then thrown by the baffles, *kk*, and a ring lying above and is thrown together into the middle. The oil therefore makes a circuit and during this circuit there is so intensive a mixing and so powerful an agitation, and thereby so intimate a bringing in contact with the atmospheric air as can be obtained by no other machine and can be accomplished in no other way. Therefore this machine adapts itself very well to the purifying of oil; and in addition to that can also be used for the mixing of varnish or lacquer with colors. The stock company above named builds this 'cataract machine' of from twenty to four hundred
2854 liters capacity, and such a machine of one hundred to one hundred twenty-five liters capacity with iron vessel and rotating cover, together with the large driving wheel for hand use costs 250 marks f. o. b. Barell. Larger machines are delivered, provided for power driving by means of pulleys."

That is the description and the apparatus shows very clearly that we have there a powerful agitation, that agitation especially adapted for the entraining of air because of the construction shown, that is, the upright baffles and the rotating ring which serves also as a horizontal baffle, and, as described in the account, the oil thrown first to the side by centrifugal power is then deflected and thrown in by reason of the horizontal baffle and that action of the vertical baffle; and, as stated in the description, the oil makes a complete circuit and thereby entrains the air and is brought in most complete contact with atmospheric air. This is adapted for the carrying out of aeration by agitation and we will show the Everson process with the aid of it.

Mr. Williams: You said agitation by aeration. You did not mean that; you meant aeration by agitation.

A. I meant it the other way.

Mr. Williams: Just change it, if you please.

Mr. Scott: If there is no objection to the photographic copy instead of offering the whole book I would like to offer the photographic copies of the pages.

2855 Mr. Williams: I think you ought to include the previous page which has the greater part of the description.

Mr. Scott: I will add that to it, the preceding page.

Mr. Williams:

Q. 135. This book, you say, has been in your library. Is it, so far as you know, a book of general circulation?

A. This book was got by me, together with other books on these technical industrial subjects, from a bookseller in Germany and undoubtedly it has gone into general circulation in the linseed oil industry. It is by a standard author, quite well recognized, whose works have been translated into English and are well known to everybody connected with the linseed oil and varnish industry. Andes is the name of the author. I had it within a year after it was published.

Mr. Williams: In view of the obvious irrelevancy I certainly shall make no further objection.

Mr. Scott: I have offered the photographic copies to which I take it there is no objection if I file the additional page.

The photographic copies of two pages of the book were marked defendant's Exhibit 50.

Mr. Scott:

Q. 136. On page 2 of the Everson patent, at the paragraph beginning with line 93 reference is made to the use of petroleum or of the liquid constituents thereof like paraffine oil. I think you
2856 referred to that passage yesterday, but I do not know that you discussed it in full, the nature of the oils that are indicated by the language I have just quoted.

A. I had not finished my prior art apparatus.

Q. 137. You hadn't? I thought that was the last thing you had. Well, postpone that question, then.

I come now to the prior art apparatus to be found in the metallurgical industry, and I have a copy of Ure's Dictionary of Arts and Manufactures and Mines, published in 1860, in which we have forms of rotating blade agitators, and in which we have forms of separating boxes or spitzkasten, both of which forms of apparatus are of interest in connection with the descriptions in the Everson patent. The first of the rotating apparatus were designed for other purposes, but are entirely adaptable to the purpose which we have in mind at the moment, which is the rapid rotation with entraining of air by means of rotating blades. On page 356 is shown such a form of apparatus, figure 1419. There it is used for other purposes, and it has a cap, but with that cap removed it would be perfectly adaptable for the purpose of aeration, having blades rotating very analogous to the forms of apparatus we have in mind. This illustration is found on page 356 of Ure's dictionary, volume 3, figure 1419. The illustrations of the separating boxes known as spitzkasten are found on page 332 of the same volume.

Q. 138. Give the number of the figure please?

2857 A. Figures 1379 and 1380, and on page 335, figure 1385. There we have a combination of spitzkasten boxes operated together just as is shown in some of the illustrations of the patent in connection with this formation of aerated froth and collecting the same and separation from the gangue material.

Q. 139. Is that all you wish to refer to, doctor?

A. That is all I wish to refer to.

Q. 140. Then point to the court the different illustrations before we pass on, the pictures are so small you can put the book on the edge of the desk?

A. Very well. The one illustration is of the rotating blade apparatus, and the other two are of the separating boxes.

The Court:

Q. 141. Well, this is simply for the purpose of showing that at the time of this invention——

Mr. Scott: The patent was in 1885.

The Court: At the time of that patent there were such appliances?

Mr. Scott: That is the object.

The Court: I have no doubt you can find such things in different branches of the art.

The Witness: This is all metallurgical.

The Court:

Q. 142. The chemistry part of it, I suppose?

A. Yes, sir.

Mr. Scott:

Q. 143. Did you state who that dictionary was published by?

2858 A. Ure's dictionary, edited by Robert Hunt. This is already the fifth edition of Ure's dictionary, published in 1860.

Q. 144. You have no reproduction of those views?

A. No, I haven't.

Mr. Scott: We will have them prepared and offer them later.

Mr. Williams: You did not state what purpose they were used for?

The Witness: These were used for metallurgical purposes, not exactly as they would be used for the purpose referred to in the patent, but are entirely adaptable for those, by reason of their construction.

Mr. Scott:

Q. 145. Are they agitating mechanisms?

A. I am referring particularly to the agitating mechanisms.

Q. 146. What are they described there for, agitation or for what purpose?

A. This was employed for the excluding of the fine refuse and slime ore by rapid rotation, as it is stated.

Q. 147. What are the spitz boxes that you referred to used for?

A. They were used for what might be called classifying the ore according to the different grades of fineness.

Q. 148. Does that complete your discussion of the apparatus?

2859 A. No, I have yet one more. Now, we go away back to the 16th Century, and refer to the great chemist of the sixteenth century, Agricola, who was a great authority on chemistry as it existed in that day, and I will refer to the translation of Agricola's work on the Metallurgical Art, first published in 1556, 361 years ago, and I have one of the illustrations of this work of Agricola now for the first time, I believe, in complete English form of translation, and this illustration shows me very clearly the exact form of rotating paddle adapted for use for agitation with entraining of air—exactly the form that is used in a number of pieces of apparatus which we are using at the present time, and the apparatus is described here—here are the upright axles, and the large rotating one, and the paddles and this was primarily of the year 1556, and appears in the English translation of Agricola's Metallurgical Art, which has been issued by Herbert Clark Hoover in 1912.

Mr. Williams: Where is the original book?

The Witness: The original book is on the table.

Mr. Williams:

Q. 149. Do you remember the page?

A. 299. 299 is the page.

Q. 150. When was this book published?

A. It is dated on the front page.

Mr. Scott: 1912. We are quite unable to prove the fact that this book was originally printed in 1556.

Mr. Williams: You could call Mr. Hoover, couldn't you?

2860 Mr. Scott: Mr. Hoover could not prove it either. It is a book that exists only in museums and on collectors' shelves; it being a well known fact we thought possibly you would stipulate the date of Agricola.

Mr. Williams: It is quite evident, your honor, that it is not capable of proof and there is no proof as it stands, as to the publication prior to our invention, and I have not read the article. It is a very interesting picture. I am not prepared to say whether we will let it in without objection or not, but we will give that matter consideration.

The Court: I remember in the Hyde case you went back to Herodotus.

Mr. Williams: Yes, sir. (Laughter.)

Mr. Scott: If I remember correctly, you failed to prove the date of Herodotus's birth also.

Mr. Williams: I will look at the book. I will move to strike it out after I read it if I think necessary.

Mr. Scott: You can take the book home with you.

The Court: Do you offer this exhibit?

Mr. Scott: Yes, sir, I offer the photograph of the illustration from the work of Agricola.

The Court: It will be admitted tentatively.

Photograph from work of Agricola admitted in evidence and marked Defendant's Exhibit No. 51.

2861 The Witness: That completes my statement on that subject.

Q. 151. Referring to this Everson patent, line 93, page 2, will you explain a little more fully the character of the oils that are indicated by the expression "petroleum or a liquid constituent thereof, like paraffine oil."

A. We have that same expression—we have that form of expression in two places; in line 75 also: "When petroleum or a constituent thereof is used," indicating that Mrs. Everson contemplated the use of any petroleum fraction that would be found adapted for the purpose. We have it also in line 93: "In the use of petroleum or liquid constituent thereof," and she takes the case of paraffine oil as one of those liquid constituents of petroleum. I gave in the discussion of this patent yesterday the calculation that if you take the petroleum which she used, and herein referred to specifically as used in the particular experiment mentioned, an oil of 30° Be., and as stated here there was 17 per cent by weight of the ore taken. I also said that if you took a lighter fraction or a constituent of petroleum of lighter gravity, the weight would reckon out as less than that; for instance, if you took 40° Be., which is about the heaviest gravity of the very heaviest kerosene, which is frequently called paraffin, and in England is called paraffin oil—the calculation comes out differently. The actual specific gravity corresponding with the figure 40° Be. is .8235, and calculating the weight of a gallon
2862 of oil or liquid of that gravity, and calculating from that the percentage on to a ton of ore, you get 15.9 per cent instead of 17. Of course there are kerosenes which run from 40 Be. up to 54 and 55 and more. I can readily substantiate that by reference to standard works on petroleum recently issued of the highest authority, as to what are the gravities of commercial kerosene oil as made from different types of crude oil; it would range from 40 to 58 gravity.

Mr. Williams: I move to strike that out because we are not concerned with what kind of a kerosene *are* made today, but only with the kinds of kerosene that were made in 1886.

The Court: Well, it may be illustrative. Of course the court knows and we all know that there is a time in this case to which the evidence must relate, but it may be illustrative. He has a right to discuss the art of today and contrast it with what it was then, without it perhaps being so very material to this issue. The motion will be denied. If it is not entitled to any consideration, the court will give it none in making up its decision.

Plaintiff excepted.

Mr. Scott:

Q. 152. Doctor, you may explain the expression?

A. I will say that I know of my own knowledge what kerosene was in 1885.

Q. 153. Then you may state, if you will, what kerosene was in 1885, and other petroleum constituents as referred to here?

2863 A. Kerosene in 1885 as I was acquainted with it—it practically all was made from Pennsylvania oil—it ranged considerably above 50° Be. in gravity; distinctly above.

Q. 154. Did you explain this Baume scale of liquids lighter than water, such as these oils that you are speaking of, as to the numbers indicating the Baume degree increases, the substance is heavier or lighter?

A. As the numbers increase the substance is lighter.

Q. 155. That is, 50° oil is lighter than 40° oil?

A. Yes. The ordinary gasolene which is sold today is ordinarily 62° Be.; a very light gasoline may be up to 80° Be., and the extremely volatile material which is now being made on a large scale from casing head gas by pressure and chilling runs up to 90° Be., which is very, very light. Then we go down to the range of 50° Be. in kerosene oils, or a little over, and we get down below that to 30° Be. and lower than that for lubricating oils.

Q. 156. Was there any difference in the amount of volatile constituent in kerosene in 1885 and today?

A. No, not that I am aware of. The same range is found in crude oils now as it was then.

Q. 157. I meant in the manufacture of kerosene as a finished product; I think you call it flash point—was its flash point higher or lower than it is now?

A. The grading of kerosene by means of a flash point was in current use at that time, and they were carefully brought

2864 within a space range by the exclusion of their volatile portions, so as to conform to the legal fire test or flash test.

Q. 158. I would like to refer you, doctor, to two newspaper articles that are in evidence in the Hyde case; they have become known in this suit as the Fryer Hill publication and the Criley-Everson publication, and if you will explain to the court the nature of the disclosure of the process?

A. The Fryer Hill publication appeared in October, 1889, in the Daily Herald Democrat of Leadville, Colorado, and is headed: "An Important Invention." After referring to the particular ores which are important to be treated, we find the following statements in regard to this process or invention:

"The first unimportant means of testing the new system having proven so incontestably the correctness of the theory, other larger and more capable means have been employed. The whole system of concentration appears to be based upon the recognized affinity of the lighter forms of sulphuret in silver ores for oil. Petroleum is the oil now being used for the purpose by the parties having these experiments in charge, and appears from its density to possess the

requisite adhesiveness to effect the result desired. The ore is first crushed and rolled to such a degree of fineness as to enable it to pass through a 40 mesh screen, and while dry is thoroughly mixed with oil, after which it is placed in a circular tank or receiver, through the center of which runs a rotating hollow tube. To
2865 the bottom of this tube is attached on two opposite sides a couple of fans, the lower edges of which are unevenly cut, in order to send in the revolution the lighter particles of the ore and the oil mixed to the outer sides of the drum or cylinder. This hollow rotating tube——"

The Court: This is already in the record?

Mr. Scott: This is already in the record.

The Court: I don't see any necessity of the doctor reading it; it is in there. Any comment he wants to make——

The Witness: I will then proceed with the comments.

The Court: It is already in the record; we have it before us.

A. (Continuing:) I would call particular attention to that portion of the account which begins: "The action of the revolving tube" which is the tenth line, "the action of the revolving tube, the fans and the injected acidulated steam causes the lighter portions of the mineral bearing oil to float to a point just above the center of the receiver, where there are suspended two semicircular doors which, when the oil has passed above them, laden with its precious freight, are raised and the superfluous water allowed to drain through slight perforations in the bottom of the semi-circular doors, after which the mineral-laden oil is carefully removed to settling tanks" and so on—That is not material. Now I desire to comment on it in this way. We have described there a form of apparatus involving
2866 rapid agitation and involving at the same time aeration. The conditions are to be recalled, that is we have this revolving tube with fans and injected acidulated steam. Under this condition there is no doubt but what we have the conditions for the aeration of the mixture and the production of the froth. If the froth rises and the construction of the apparatus—I should say, before going on farther the semi-circular doors as first in position act as baffles. They hang vertically; they interrupt the rotary motion of the flowing pulp and undoubtedly act in the entraining of air and in that way we get the result which is noted. When the froth has formed, which is of course mineral-bearing froth under this condition, these doors are to be raised. Now, I want to make some comment on that latter portion, then, of the operation. The language describing the results of the operation of the Everson process, as here given in the Fryer Hill publication, and the action of the revolving tube, the fans and injected acidulated steam, it is stated cause "the lighter portion of the mineral-charged oil to float," and then, as stated before, that is taken off. Now, in the first place, there are no lighter portions of a layer of petroleum oil, such oil as is used here, if we consider the question of oil only, as petroleum oils do not stratify in layers of unequal gravity. But if the oil were thoroughly aerated, as is indi-

cated by the reference just preceding, by the action of a revolving tube, the fans and the injected acidulated steam, then the
2867 aerated layer, or air froth, would be lighter than either any excess oil or water, and would float, as stated in the account of the results obtained. I desire to emphasize that fact, that it is impossible to consider that expression "the lighter portion of the mineral-charged oil," to refer to an oil layer, because oil don't stratify. In the second place, the use of the word "float" here used is understood when one considers the production of an aerated air and oil froth, and has no proper meaning if we simply suppose that an oil layer of the compact Elmore type is to be understood as the layer which is taken off. The word "float" indicates that we have a mass of aerated, mineralized material, or "bubbles," in other words, coated.

In the third place, the reference to this lighter portion which floats to the top as the "mineral-laden" shows it to have been an air froth, mineral-laden, because of the selective action of the oil and the agitation used. An un-aerated layer of compact oil, like that used in the Elmore process, would carry the mineral particles in the lower layers rather than in the upper layers, as has been noted by various ones of the plaintiff's expert witnesses as well as by counsel in discussing the Elmore layer, and overloading of that Elmore layer with mineral particles.

In the fourth place, drainage away from a froth "through the slight perforations in the bottoms of these semi-circular doors" is easy and practical, whereas drainage of the water from a compact oil layer by the means indicated would be very difficult to
2868 effect, as the oil would pass out largely with the water through the perforations in the doors. And in the fifth place, mineral particles from the lower strata of the assumed compact oil layer would speedily clog the "slight perforations" in the semi-circular doors; or, if they passed through would make it impossible to get clean tailings. As the ore is stated to have been a silicious one, the tailings would have been very light colored and the contamination would at once be apparent. I conclude, therefore, if, as stated in this Fryer Hill publication, the "lighter portions of the mineral-charged oil" float off, it is because a froth has formed which becomes "mineral-charged." That seems to me to be the clear interpretation of these words.

Q. 159. You have an apparatus of the character described here, doctor?

A. That apparatus has been constructed and was shown in the Miami case, an apparatus constructed as nearly as might be according to the description given in the Fryer Hill publication, and it will be shown here as illustrative of the Everson process.

Q. 160. It will be shown here and operated as soon as it is ready?

A. Yes.

Q. 161. Have you considered this Criley and Everson publication appearing on page 740 of the Hyde record?

A. In the Criley and Everson publication, in which we have of course the direct association with the name——

[Copy of cover of volume 6 of transcript of record.]

2868½ United States Circuit Court of Appeals for the Ninth Circuit.

No. 3081.

BUTTE AND SUPERIOR MINING COMPANY, Designated as Butte and Superior Copper Company, Limited, a Corporation, Appellant,

vs.

MINERALS SEPARATION, LIMITED, a Corporation; MINERALS SEPARATION AMERICAN SYNDICATE, LIMITED, a Corporation, and Minerals Separation North American, a Corporation, Appellees.

Substituted Pursuant to Order Filed March 19, 1918, for Incorrect Copy Filed November 10, 1917.

TRANSCRIPT OF RECORD.

Volume 6.

(Pages 2869 to 3540, Inclusive.)

Upon Appeal from the United States District Court for the District of Montana.

Filed Mar. 19, 1918. F. D. Monckton, Clerk.

—"Everson," we have no forms of apparatus described. We
2869 have several very important statements of conditions. The ore was crushed and passed through a 60 mesh screen dry and thoroughly mixed with black, thick oil, presumably a petroleum product. To water heated to near boiling was added enough sulphuric acid to give it a tartish taste. This acid and water was then mixed with the mass of oil and ore. Now, there is entire absence of any account of the form of apparatus or how the agitation was carried out, but the result alone is stated. A thick scum of sulphurets rose to the surface and was skimmed off, leaving the hitherto black ore as white as snow, in fact pure silica. These are the vital elements in this statement.

Q. 162. Do the results stated in the sentence you have just quoted beginning "a thick scum"—Does that convey any information regarding the operating process?

A. That shows I think, clearly that it was the same process as would have been carried out with the same apparatus which is figured in this other publication, and the results would have been the same as there obtained. The scum is the froth in this case.

Q. 163. If you will refer once more to the Everson patent, page 607 of defendant's record in the Hyde case, on page 1 of the patent, beginning at line 17, extending to line 20, the same page, beginning at line 81 extending down to about 86, the patentee makes statements regarding the character of oils adapted for her process. Will you state how extensive a category of oily substances is set forth in
2870 the language used in these passages?

A. The list is a very comprehensive one. In line 17 we have the expression "a fat or an oil, either animal, mineral or vegetable, or a fatty constituent or acid of an animal, or vegetable fat or oil, or any constituent of a mineral oil." These terms cover all of the animal and vegetable oils and their constituents like oleic acid, which is a fatty acid derived from an animal and a vegetable oil. And that covers all of the petroleum fractions because "any component of a mineral oil" is there mentioned. And the same thing is used with a little more expressive statement of particular oils, in line 80:

"I have used petroleum and one of its several constituents viz., parafline oil." But the whole range of petroleum constituents can be covered by that earlier language, also tallow in melted form, lard, lard oil, red oil, meaning thereby impure oleic oil, cottonseed oil, castor oil, sperm oil, linseed oil and some combination of these with each other. That gives us a range of fatty oils or what might be called fixed oils, of both animal and vegetable origin. It does not specify an essential oil or one of the turpene type oils, but that is covered under the broad statement "fat or oil, either animal, mineral or vegetable."

Mr. Scott: I think now, as the continuity of our case has been broken a little through necessity, I will discontinue the examination of Dr. Sadtler for the time being and put on another witness in order to get the things before the court that the doctor will want to

2871 refer to before he finishes, and opposing counsel may either cross examine now or later as they choose.

Mr. Williams: I think it will be better to postpone the cross examination until the completion of the deposition, as matters stand. Of course there may be some incidents that require it.

The Court: This promises to be a long case and you ought to have your witnesses in order and know what they are going to testify to and have everything ready.

Mr. Scott: The evidence is all ready. It is simply the mechanical work that is necessary.

Witness temporarily excused.

JOHN WARNE PHILLIPS, a witness called on behalf of the defendant, being first duly sworn testified as follows:

Direct examination.

By Mr. Scott:

Q. 1. State your full name.

A. John Warne Phillips.

Q. 2. Will you kindly state your occupation?

A. I am connected with Mariner & Hoskins, chemists and engineers of Chicago, at the present time, and represent them here now at this case.

Q. 3. And what is the nature of your duties or profession?

2872 A. I graduated from Princeton and spent two years there as a post graduate and was instructor there for three years and then I accepted a position of professor of chemistry and physics in the University of Nevada and taught there for ten years and then I carried on metallurgical operations in plants of my own, and for several years I was manager of the Overland Mining Company, of Gold Hill, Nevada, and for four years I have been connected with the engineering firm in Chicago of Mariner & Hoskins, as chemical engineer.

Q. 4. Have you made any investigations of the character of froths produced in the flotation process?

A. I have.

Q. 5. Just briefly, without going into details at present, just state the nature of the operations you carried out.

A. I used several—I have used three varieties of oils, practically on the same charge, on a laboratory scale. The charge used was 60 grams of ore, 250 cc. of water and copper sulphate in the proportion of one-fifth of a pound of copper per ton of ore, and sulphuric acid in the proportion of 8 lbs. of 60° Be. sulphuric acid per ton of ore. I added the pulp of course first to the vessel and then the water and then the copper sulphate and then the acid and agitated for one-half minute so as to thoroughly stir the pulp with the solution and then I add the oil and agitate it for eight minutes, and most of the tests, most all of the tests were carried on in that method, that procedure.

2873 Q. 6. What was the ore that you used?

A. The ore used was a Butte & Superior ore, I think mill heads, lot No. 2. It assayed 16% of zinc, if I remember rightly, about—Its fineness was 6% on an 80 mesh and about 60% through a 200 mesh.

Q. 7. And what kind of an apparatus did you use for these experiments?

A. We used an ordinary soda fountain or bar mixer, electric mixer, and for the vessel was used a rectangular-shaped vessel, I think used for a battery jar, about 5½ inches high, 2 inches wide and about 2½ long, that is, a rectangular shape.

Q. 8. And you made photographs, did you, of these froths?

A. Made photographs.

Q. 9. Will you describe the character of the different photographs you made, the views?

A. We made three series of photographs. The first was taken, a photograph of the froth through the side of the vessel and a magnification of 15 diameters, or that would be 225 times, magnified 225 times. And all photographs of that character are labeled No. 1, or series 1.

Now, series 2, photographs were made through the sides of the vessels in the same way, but a magnification of five diameters or 25 times; and photographs No. 3 series, 3 was made of the top of the froth by using a prism and taking the top view of the froth. They were not magnified, supposed to be normal. Now, these mag-

2874 nifications are not absolute, but very near. We determined the magnification by taking a photograph of a scale in the place where the froth or object was, and measuring the image of this scale, on the ground plate of the camera, and taking the ratio between those two. That is the method we obtained of magnification, particularly five magnification and fifteen magnification.

Q. 10. Were you present throughout those operations of making these different froths, and supervising it or performing it?

A. Yes, at all times.

Q. 11. And the same is true of the making of the photographs?

A. The making of the photographs; I was present when the exposures were made and instantly after the exposure I put a number on the negative before it was printed.

Q. 12. I will show you some of these photographs and ask you if you can identify them. The distinguishing numbers are different in each case?

A. Yes.

Q. 13. So if you identify them by number it will be definite, will it?

A. Yes.

Q. 14. Now, will you kindly state what this photograph bearing the number 16-3 is?

A. That is a top view of froth containing one-tenth of 1%, oil mixture No. 3.

Q. 15. And will you state what that oil mixture is?

A. What it comprises?

2875 Q. 16. What oils and what proportions?
A. I can't remember that.
Q. 17. Refer to your notes.
A. The oil mixture contained 70% crude fuel oil, 18% yaryan pine oil and 12% refined kerosene.
Q. 18. And the proportion is one-tenth of 1%?
A. Yes.
Q. 19. Now I hand you another one which is marked with the number 17-3 and ask you to identify that and state what that represents.
A. 17-3 is the same but contains three-tenths of one per cent. of oil mixture.
Q. 20. Of the same oil mixture?
A. Oil mixture No. 3.
Q. 21. Now I hand you another photograph which bears the designation 1-3.
A. That is a photograph, top view, of froth containing 4/10 of 1% oil mixture.
Q. 22. The same oil mixture?
A. No, not the same oil mixture. The oil mixture of this other varies just slightly in containing 17% yaryan pine oil and 13% kerosene instead of 18% and 12%.
Q. 23. Now I hand you a photograph marked 2-3.
A. That is a top view of the same character of charge but containing one-half of 1% of oil mixture.
Q. 24. What oil mixture was that, the same as number——
A. The same as No. 1-3.
2876 Q. 25. Now I hand you another photograph marked 3-3.
A. That is a top view of froth containing six-tenths of 1% oil mixture.
Q. 26. The same oil mixture?
A. The same oil mixture as No. 1, 2 and 3.
Q. 27. I hand you another photograph designated 4-3.
A. That is the same oil mixture. The same view, but containing 1% of oil mixture.
Q. 28. As one oil mixture?
A. As one oil mixture.
Q. 29. The same oil mixture as 1, 2 and 3?
A. Yes, the same charge.
Q. 30. Now I hand you another photograph bearing designation 8-3.
A. That is the same as—top view of froth and containing 1¼% oil mixture, same oil mixture.
Q. 31. Photograph bearing designation 5-3.
A. That is a top view of froth containing 1½% of the same oil mixture.

Mr. Scott: I think I will offer the set right now, to avoid confusion. I offer in evidence the photographs just identified by the witness and ask that each be marked as a separate exhibit in the following order: Photographs 16-3, 17-3, 1-3, 2-3, 3-3, 4-3, 8-3, 5-3.

The photographs were admitted in evidence and marked Defendant's Exhibits 52 to 59 inclusive.

2877 Mr. Scott:

Q. 32. Mr. Phillips I hand you a photograph marked 16-2 and ask you to identify and describe what it represents.

A. That is a side view of the froth taken from the sides of the vessel containing one-tenth of 1% of oil mixture No. 3 and a magnification of five diameters or 25 times.

Q. 33. You say oil mixture No. 3; is that the one you described before?

A. The first, yes.

Q. 34. That is the first oil mixture you described before?

A. Yes.

Q. 35. This picture was taken, how did you say; through the side?

A. Through the side of the vessel.

Q. 36. Of the glass jar in which it was made?

A. Yes. And the dark line below shows water below the froth, this dark spot?

Q. 37. And how high that line of froth extends on the picture?

A. The froth extends along this line here, right along here, and all of this froth, all this frosting above is the creep on the side of the vessel.

Q. 38. Will you please make a mark on the photograph, a letter or a number or something to show the upper boundary of the froth?

A. This froth was only a quarter of an inch in depth, con-
2878 sequently the froth in the picture should not be over an inch and a quarter in depth to be five diameters.

Mr. Scott: The witness has made a mark on the photograph and written the word "top" to indicate the upper surface or edge of the froth.

Q. 39. Now, what is that appearance above the top of the froth that is indicated in the upper part of the photograph?

A. That is the creeping of the oil and ore on the inside of the vessel, up on the inside of the vessel, during agitation. When it settles down it comes down and leaves this frosting on the inside of the vessel.

Q. 40. It is merely the dirty side of the vessel?

A. Dirty glass inside.

Mr. Scott: I offer this photograph marked 16-2.

Said photograph was admitted in evidence and marked Defendant's Exhibit No. 60.

Mr. Scott:

Q. 41. I hand you another photograph marked 17-2 and ask you to state what that represents.

A. This represents the same view and the same oil mixture but contains three-tenths of 1% of oil.

Q. 42. Of the same mixture as that of No. 16-2?

A. Yes, of No. 16-2.

Q. 43. Will you indicate on this photograph also the top of the froth if it shows there or does it extend away to the top of the picture?

A. No, it doesn't extend away to the top of the picture.

2879 Q. 44. Is it possible to tell just where the froth does leave off and where the dirty side of the jar begins?

A. It is difficult in this case. I think the froth is about along on this line, right in through there; this represents this top of the froth. The average depth of the froth was 2½—or one-half an inch, I should say. One-half inch magnified then, five times would make it 2½ inches deep, so these marks through there, the openings, to my mind would indicate the top of the froth.

Q. 45. Just make a mark on that similar to the other one.

(Witness marks the photograph.)

Mr. Scott: I offer this photograph marked 17-2.

Said photograph was admitted in evidence marked Defendant's Exhibit 61.

Q. 46. I hand you photograph marked 1-2 and ask you to identify it.

A. This is the same view magnified five diameters, 25 times, but contains four-tenths of 1% oil mixture, the second oil mixture.

Q. 47. Can you indicate on this photograph about the position of the upper surface of the froth?

A. I think this is along there near the top of the picture.

Q. 48. This one you named the amount of oil, didn't you, as four-tenths of 1% of the second oil mixture?

2880 A. Yes, four-tenths of a per cent.

Mr. Scott: I offer this photograph bearing No. 1-2.

Said photograph was admitted in evidence and marked Defendant's Exhibit No. 62.

Mr. Scott:

Q. 49. I hand you another photograph bearing No. 2-2 and ask you to identify it and describe it.

A. This is the same view taken through the side of the vessel magnified 25 times and contains one-half of 1% of oil mixture.

Q. 50. Can you identify the position of the top of the froth?

A. I have.

Q. 51. By an ink mark and the word "Top"?

A. Yes.

Mr. Scott: I offer this photograph marked 2-2.

Said photograph was admitted in evidence and marked Defendant's Exhibit 63.

Q. 52. I hand you a photograph marked 3-2?
A. This was taken through the side of the vessel, magnified 25 times, and contains six-tenths of one per cent. oil mixture. The froth extends nearly to the top of the picture.

Mr. Scott: I offer this photograph in evidence.

Photograph admitted in evidence and marked Defendant's Exhibit 64.

2881 Q. 53. I will ask you to describe this photograph, marked 4-2?
A. This was taken through the side of the vessel, magnified 25 times, and contains one per cent. of the oil mixture.
Q. 54. The froth extends to the mark you have just put on the picture, does it?
A. Yes.

Mr. Scott: I offer the photograph marked 4-2 in evidence.

Photograph admitted in evidence and marked Defendant's Exhibit 65.

Q. 55. I hand you photograph marked 8-2 and ask you to describe it?
A. This is taken through the side of the vessel, magnified 25 times and contains one and a quarter per cent. oil mixture.
Q. 56. When you say contains one and a quarter per cent., you mean, do you not, that the froth was made by using one and one quarter per cent. of oil relative to the weight of the ore?
A. Yes, sir.
Q. 57. You don't mean that the froth itself contains one and a quarter per cent.?
A. No; the charge was made up by using one and a quarter per cent. of oil to the amount of ore used.
Q. 58. Does the froth extend to the point you have designated on this photograph?
2882 A. To the top, yes, sir.

Mr. Scott: I offer the photograph 8-2 in evidence.

Photograph admitted in evidence and marked Defendant's Exhibit No. 66.

Q. 59. I hand you a photograph marked 5-2 and ask you to describe it?
A. This is taken through the side of the vessel, magnified 25 times, and the charge was made up to contain one and a half per cent. of the oil mixture.
Q. 60. Of the same mixture?
A. Of the same mixture as the preceding.

Mr. Scott: I offer this photograph marked 5-2 in evidence.

Photograph admitted in evidence and marked Defendant's Exhibit No. 67.

Q. 61. Now, Mr. Phillips, there was a little change in the oil mixture, as I remember it, the photographs numbered 16 and 17——

A. Were made from the oil mixture No. 3.

Q. 62. And the photographs 1, 2, 3, 4, 8 and 5——

A. Were made up from another oil mixture which was not numbered, just labeled oil mixture, and that oil mixture contains 70 per cent. of crude fuel oil, 17 per cent. of Yaryan pine oil and 13 per cent. of refined kerosene.

Q. 63. And you described the mixture that was used before for 16 and 17?

2883 A. I did, yes, sir, mixture No. 3.

Q. 64. I hand you a photograph marked 16-1, and ask you to state what it represents?

A. This is a photograph of the froth taken through the side of the vessel, magnified 225 times.

Q. 65. That would be 25 diameters?

A. Fifteen diameters; and it contains one-tenth of one per cent. of oil mixture No. 3. All pictures marked 16—16-1, 16-2, and 16-3—were taken from the same experiment or the same froth.

Q. 66. And the numbers 1, 2 and 3 indicate?

Indicate the series of the pictures and the first number, 16, represents the test.

Q. 67. And all pictures numbered 1 are what kind of views?

A. Taken through the side of the vessel, magnified 225 times. Pictures marked 2 are taken through the side of the vessel, magnified 25 times, and all pictures numbered 3 represent the top view of the vessel of natural size.

Q. 68. This 1, 2 and 3 that you just referred to is the second of the two figures which appear on the photograph?

A. The second numerals.

Q. 69. And the first numeral appearing on the photograph designates the particular test?

A. The particular test and the particular charge.

Q. 70. And wherever the same number is the same on two or three photographs, they are photographs of the same test?

2884 A. Of the same test, the same froth.

Q. 71. You just gave the proportion of the oil?

A. Yes, one tenth.

Q. 72. Does that froth extend clear to the top of the picture I hold in my hand now?

A. I should say nearly; it is perhaps to there.

Q. 73. Will you explain to the court, by reference to these experiments which were performed yesterday—these illustrations of the California Journal which are now standing here—explain to the court just what the indefiniteness is in telling where the froth leaves off at the top?

A. Here is an example here; taking the froth here—that would occur in the picture, and still the top of the froth would be down

somewhere here, and we have to take really the measurement of the thickness of the froth.

The Court: That was made by the court tipping it up a while ago. You mean the upper part?

A. The upper part, yes, sir.

Mr. Scott: I offer this photograph marked 16-1 in evidence.

Photograph admitted in evidence and marked Defendant's Exhibit No. 68.

Q. 74. I hand you another photograph marked 17-1. Please describe that.

A. 17-1 is a side view, taken through the vessel, magnified 225 times. The charge was made up of three-tenths of one per
2885 cent oil mixture No. 3 and the picture does not extend to the top of the froth.

Mr. Scott: I offer this photograph marked 17-1 in evidence.

Photograph admitted in evidence and marked Defendant's Exhibit No. 69.

Q. 75. I hand you another photograph marked 1-1, and ask you to describe it.

A. This is taken through the side of the vessel, magnified 225 times. The charge is made up of four-tenths of one per cent oil mixture. The picture does not extend to the top of the froth.

Mr. Scott: I offer this photograph marked 1-1 in evidence.

Photograph admitted in evidence and marked Defendant's Exhibit No. 70.

Q. 76. I hand you a photograph marked 2-1 and ask you to describe it?

A. Taken through the side of the vessel, magnified 225 times. The charge is made up of one-half of one per cent oil mixture and the photograph does not extend to the top of the froth.

Mr. Scott: I offer in evidence photograph marked 2-1.

Photograph admitted in evidence and marked Defendant's Exhibit No. 71.

2886 Q. 77. I hand you a photograph marked 3-1 and ask you to describe it?

A. Taken through the side of the vessel, magnified 225 times. The charge is made up of six-tenths of one per cent oil mixture, and the photograph does not extend to the top of the froth.

Mr. Scott: I offer in evidence photograph 3-1.

Photograph admitted in evidence and marked Defendant's Exhibit No. 72.

Q. 78. I hand you a photograph marked 4-1.

A. Taken through the side of the vessel, magnified 225 times. The charge is made up of one per cent oil mixture. The photograph does not extend to the top of the froth.

Mr. Scott: I offer in evidence photograph 4-1.

Photograph admitted in evidence and marked Defendant's Exhibit 73.

Q. 79. I hand you a photograph marked 8-1 and ask you to describe it?

A. Taken through the side of the vessel, magnified 225 times. The charge is made up of one and a quarter per cent oil mixture. The photograph does not extend to the top of the froth.

Mr. Scott: I offer photograph 8-1 in evidence.

Photograph admitted in evidence and marked Defendant's Exhibit 74.

2887 Q. 80. I hand you a photograph marked 5-1 and ask you to describe it?

A. This was taken through the side of the vessel, magnified 225 times. The charge is made up of one and a half per cent oil mixture. The photograph does not extend to the top of the froth.

Mr. Scott: I offer in evidence photograph marked 5-1.

Photograph admitted in evidence and marked Defendant's Exhibit 75.

Q. 81. I hand you a photograph marked 21-3 and ask you to describe what it represents?

A. 21-3, is a top view of the froth. The charge is made up of one-tenth of one per cent of oil mixture No. 3.

Q. 82. The photographs which I hold in my hand were they of the same tests?

A. No, no—I beg your pardon; instead of oil mixture, this is pine tar oil. The label of the oil it is made of is marked wood tar oil. One-tenth of one per cent wood tar oil.

Q. 83. You have stated that this was a top view?

A. Yes, a top view.

Q. 84. And these top views are substantially of the same size as the original?

A. Yes, the natural size.

Mr. Scott: I offer this photograph 21-3 in evidence.

2888 Photograph admitted in evidence and marked Defendant's Exhibit 76.

Q. 85. What can you say as to the character of the float in that photograph 21-3 which is now designated exhibit 76?

A. It was a very watery froth, and the bubbles were not persistent, and it was very tender and easily broken down, and disintegrated in a short time.

Q. 86. Did it seem to carry much mineral or little mineral?

A. It seemed to carry quite a great deal of mineral, it was heavily loaded.

Q. 87. Was it voluminous or heavy or thin?

A. No, it was very thin only a quarter of an inch in depth.

Q. 88. I hand you a photograph marked 22-3, and ask you to describe what is there represented.

A. This is a top view of the froth, the charge made up of three-tenths of one per cent wood tar oil.

Q. 89. What can you say as to the character of a froth that was formed in that instance?

A. The froth was very easily broken down; the bubbles on top disappeared, but the froth was more voluminous than in 21-3.

Mr. Scott: I offer this photograph 22-3 in evidence.

Photograph admitted in evidence and marked Defendant's Exhibit No. 77.

2889 Q. 90. I hand you photograph marked 9-3 and ask you what that represents?

A. This is a top view of the froth. The charge was made up to compose four-tenths of one per cent pine tar oil. Both of those oils were purported to be the same, but the vessel in which one was was labeled wood tar oil and the other pine tar oil.

Q. 91. Who was it that stated they were the same?

A. Mr. Dosenbach.

Q. 92. What can you say as to the froth that was formed in the instance of this photograph 9-3?

A. It was very permanent and persistent.

Mr. Scott: I offer photograph 9-3 in evidence.

Photograph admitted in evidence and marked Defendant's Exhibit No. 78.

Q. 93. This last one, 9-3, was made with four-tenths of one per cent oil?

A. Yes, sir.

Q. 94. The two of the previous ones of the series, 21-3 and 22-3 were made with respectively one-tenth and three-tenths.

A. Yes, sir.

Q. 95. I hand you photograph marked 10-3 and ask you to describe what is there represented?

A. The top view of the froth. The charge was made up to compose five-tenths of one per cent of pine tar oil.

Mr. Scott: I offer this photograph 10-3.

2890 Photograph admitted in evidence and marked Defendant's Exhibit No. 79.

Q. 96. I hand you photograph marked 11-3 and ask you to describe what it represents?

A. It represents the top view of the froth, the charge made up to compose six-tenths of one per cent of pine tar oil.

Mr. Scott: I offer in evidence photograph marked 11-3.

Photograph admitted in evidence and marked Defendant's Exhibit No. 80.

Q. 97. I hand you photograph marked 12-3 and ask you to describe what is represented?
A. Top view of froth, the charge made up to compose one per cent of pine tar oil.

Mr. Scott: I offer in evidence photograph 12-3.

Photograph admitted in evidence and marked Defendant's Exhibit No. 81.

Q. 98. I hand you photograph marked 13-3 and ask you to describe it?
A. This represents the top view of froth, the charge made up to compose one and a half per cent of pine tar oil.

Mr. Scott: I offer in evidence 13-3.

Photograph admitted in evidence and marked Defendant's Exhibit No. 82.

2891 Q. 99. I hand you photograph marked 14-3 and ask you to describe it?
A. Top view of froth; charge made up to compose two per cent pine tar oil.

Mr. Scott: I offer in evidence photograph 14-3.

Photograph admitted in evidence and marked Defendant's Exhibit No. 83.

Q. 100. I hand you photograph marked 21-2 and ask you to state what it represents?
A. This represents the side view of the froth taken through the vessel, magnified 25 times, the charge made up to contain one-tenth of one per cent wood tar oil.
Q. 101. That is this photograph and the following ones of the series represent the same tests that were pictured in the top views which you have just described?
A. Yes, sir. The side view of 21 is the same as the top view of 21—the same froth.
Q. 102. It corresponds to 21, in the top views?
A. Yes, sir.
Q. 103. Will you indicate about where the top of that froth comes?
A. About there.

Mr. Scott: I offer photograph 21-2 in evidence.

Photograph admitted in evidence and marked Defendant's Exhibit No. 84.

Q. 104. I hand you photograph 22-2 and ask you what it represents?

2892 A. Side view of froth taken through the vessel, magnified 25 times, and the charge made up to compose three-tenths of one per cent of wood tar oil.

Q. 105. You have indicated the top of the froth on this picture?

A. I have, yes, sir.

Mr. Scott: I offer photograph 22-2 in evidence.

Photograph admitted in evidence and marked Defendant's Exhibit No. 85.

Q. 106. Now, 21-2 and 22-2 that you have just described are side views of the same froth that was represented in the two top views that you described as being thin and tender?

A. They are.

Q. 107. I hand you photograph 9-2 and ask you to describe what is represented?

A. This is a side view of the froth, magnified 25 times, the charge composed of four-tenths of one per cent pine tar oil.

Q. 108. You have indicated the top of the froth?

A. I have.

Mr. Scott: I offer photograph 9-2 in evidence.

Photograph admitted in evidence and marked Defendant's Exhibit No. 86.

Q. 109. I hand you photograph 10-2 and ask you to describe it?

A. Side view of froth taken through the vessel, magnified

2893 25 times and the charge is made up to contain one-half of one per cent, pine tar oil.

Q. 110. The top of the froth is about where on that picture?

A. About through here. That bubble extended up on the side of the vessel.

Mr. Scott: I offer the photograph 10-2 in evidence.

Photograph admitted in evidence and marked Defendant's Exhibit No. 87.

Q. 111. I hand you photograph 11-2 and ask you to describe it?

A. Side view of froth taken through the side of the vessel, magnified 25 times and the charge made up to contain six-tenths of one per cent pine tar oil.

Q. 112. You have indicated the top of the froth, have you?

A. Yes, as near as I can.

Mr. Scott: I offer 11-2 photograph in evidence.

Photograph admitted in evidence and marked Defendant's Exhibit No. 88.

Q. 113. I hand you photograph marked 12-2 and ask you to describe it?

A. Froth taken through the side of the vessel, magnified 25 times, the charge made up to compose one per cent of pine tar oil.

Q. 114. The top of the froth appears about where as near as you can estimate?

2894 A. About there.

Mr. Scott: I offer photograph 12-2 in evidence.

Photograph admitted in evidence and marked Defendant's Exhibit No. 89.

Q. 115. I hand you photograph 13-2 and ask you to describe it?

A. Photograph of the froth taken through the side of the vessel, magnified 25 times, the charge made up to contain one half per cent pine tar oil.

Q. 116. You have indicated the top of the froth?

A. I have.

Mr. Scott: I offer photograph 13-2 in evidence.

Photograph admitted in evidence and marked Defendant's Exhibit No. 90.

Q. 117. I hand you photograph marked 14-2 and ask you to describe it?

A. This is a picture of the froth taken through the side of the vessel, magnified 25 times, the charge made up to contain two per cent of pine tar oil.

Q. 118. You have indicated the top of the froth.

A. I have.

Mr. Scott: I offer photograph 14-2 in evidence.

Photograph admitted in evidence and marked Defendant's Exhibit No. 91.

Q. 119. I hand you photograph 21-1 and ask you to state what is represented?

2895 A. Photograph of froth taken through the side of the vessel, magnified 225 times and the charge made up to contain one-tenth of one per cent wood tar oil. The photograph does not extend to the top of the froth.

Q. 120. That is on account of this being more highly magnified, I presume?

A. Yes—well, it does go to just to the top.

Q. 121. The top ends near the top of the photograph?

A. Yes.

Q. 122. This 21-1 indicates the froth that you have said was thin and tender?

A. Yes.

Mr. Scott: I offer photograph 21-1 in evidence.

Photograph admitted in evidence and marked Defendant's Exhibit No. 92.

Q. 123. I hand you photograph 22-1 and ask you to describe it?
A. This is a picture of the froth taken through the side of the vessel, magnified 225 times, the charge made up to contain three-tenths of one per cent wood tar oil. The froth extends beyond the edge of the photograph.
Q. 124. This also is one of the two froths that you referred to as being thin and tender, I think.
A. Yes, sir.

Mr. Scott: I offer photograph 22-1 in evidence.

Photograph admitted in evidence and marked Defendant's Exhibit No. 93.

2896 Q. 125. I hand you photograph 9-1 and ask you to state what it represents.
A. Picture of froth taken through the side of the vessel magnified 225 times and the charge made up to contain four-tenths of 1% of pine tar oil. The froth extends beyond the top.
Q. 126. At the top?
A. At the top; yes, sir.

Mr. Scott: I offer photograph 9-1.

Said photograph was admitted in evidence and marked Defendant's Exhibit No. 94.

Mr. Scott:

Q. 127. I hand you photograph 10-1. Please state what it represents.
A. Picture of froth taken through the side of the vessel magnified 225 times and the charge made up to contain one-half of 1% of pine tar oil; the froth extends beyond the picture.

Mr. Scott: I offer picture 10-1.

Said photograph was admitted in evidence and marked Defendant's Exhibit 95.

Mr. Scott:

Q. 128. I hand you photograph 11-1 and ask you what it represents.
A. Photograph taken through the side of the vessel magnified 225 times, the charge made up to contain six-tenths of 1% pine tar oil, and the froth extends beyond the picture at the top.

Mr. Scott: I offer photograph 11-1.

2897 Said photograph was admitted in evidence marked Defendant's Exhibit 96.

Q. 129. I hand you photograph marked 12-1 and ask you what it is.

A. 12-1 is a photograph of froth taken through the side of the vessel magnified 225 times, the charge made up to contain 1% of pine tar oil. The froth extends beyond the picture.

Mr. Scott: I offer photograph 12-1.

Said photograph was admitted in evidence marked Defendant's Exhibit 97.

Q. 130. I hand you photograph 13-1. Please state what that is.
A. Photograph taken through the side of the vessel magnified 225 times, the charge made up to contain 1½% of pine tar oil. I think the froth extends to the top of the picture.
Q. 131. Looks as if it extended just about to the top, does it not?
A. Yes, to the top of the picture.

Mr. Scott: I offer photograph 13-1.

Said photograph was admitted in evidence marked Defendant's Exhibit No. 98.

Q. 132. I hand you photograph 14-1. Please state what that is.
A. 14-1 is a photograph of froth taken through the side of the vessel magnified 225 times, the charge made up to contain
2898 2% of pine tar oil and the froth extends beyond the picture at the top.

Mr. Scott: I offer photograph 14-1.

Said photograph was admitted in evidence marked Defendant's Exhibit No. 99.

Mr. Scott: I hand you photograph marked 18-3 and ask you to state what it represents.

A. It represents a photograph of top view of froth, the charge made up to contain 25% kerosene oil.
Q. 133. The ore being the Butte & Superior as used in the other experiment?
A. No, the ore in this case was—yes, the ore in this case was the Butte & Superior ore, the same ore.
Q. 134. The acid and other elements the same as these photographs you have been testifying about?
A. All the conditions being the same except the quantity of oil and the kind of oil.
Q. 135. You said 25% kerosene?
A. 25% kerosene oil.

Mr. Scott: I offer photograph 18-3.

Said photograph was admitted in evidence marked Defendant's Exhibit No. 100.

Q. 136. I hand you photograph 18-2 and ask you to state what that represents.
A. 18-2 represents a side view of the same froth taken through the

vessel magnified 25 times, the charge made up to contain 25% kerosene oil and the froth extends beyond the picture at the top.

2899 Q. 137. Was it a voluminous froth?

A. Very voluminous froth.

Mr. Scott: I offer photograph 18-2.

Said photograph was admitted in evidence and marked Defendant's Exhibit No. 101.

Mr. Scott:

Q. 138. I hand you photograph 18-1 and ask you what it represents.

A. 18-1 represents a photograph of the same froth taken through the sides of the vessel, magnified 225 times and the charge made up to contain 25% of kerosene oil and the froth extends beyond the picture at the top.

Q. 139. I notice in this picture shining spheres. Do you know whether they are oil globules or air bubbles, or what?

A. I think they are air bubbles in contact with the side of the glass and the particles are shoved over on the side.

Q. 140. The mineral particles?

A. The mineral particles.

Q. 141. So these are like air bubbles?

A. Yes.

Q. 142. Merely displaced froth?

A. Merely displaced foam that is in contact with the glass. I would like to state, with 225 magnification, that we get very little depth of the froth. We only get a picture practically of the plane through the froth and consequently when this is photo-

2900 graphed right on the froth it comes up against the sides of the vessel and we only get the froth right at that point, at the side of the vessel.

Q. 143. You don't get into the background at all?

A. Don't get into the background at all, because at that diameter or that magnification the froth beyond soon gets out of focus. Of course we get a little depth, but it soon gets out of focus beyond.

Q. 144. I would like to ask you if you notice in any of these other pictures with smaller quantities of oil shiny spheres similar to this.

A. I have, but not so plainly as in this one.

Q. 145. I wonder if you could pick out some there that show it, some with the smaller quantity of oil.

Mr. Scott: I offer this photograph 18-1.

Said photograph was admitted in evidence marked Defendant's Exhibit No. 102.

Whereupon an adjournment was taken until 2:00 o'clock p. m.

2901 Tuesday, April 24th, 1917, 2:00 P. M.

JOHN WARNE PHILLIPS resumed the stand for further

Direct examination.

By Mr. Scott:

Q. 146. I think that before recess I had asked you about the appearance of the shiny bubbles in the 25 per cent kerosene photograph, and asked you if you had noticed the same phenomenon in any of the froths with smaller amounts of oil, and I believe this is the one that you picked out to illustrate your answer with; what is that?

A. That is 17-1, exhibit 69.

Q. 147. You may describe again how much oil is used in the making of that froth?

A. It is made up of a charge containing three-tenths of one per cent of oil mixture No. 3, and has the same magnification as 18-1, 225 times.

Q. 148. We will find that kerosene picture; is that it, 18-1?

A. 18-1, yes, sir.

Q. 149. Exhibit No. 102?

A. Yes, sir.

Q. 150. You find the shiny bubbles in them both, one with three-tenths of one per cent of the mixture and the other with twenty-five per cent of kerosene?

A. Yes, sir.

2902 Q. 151. Please show those to the court?

The Court: Those white specks you mean?

A. Yes, sir. You see these are the bubbles, and those white spots are from the reflection of the light.

The Court: Yes; that is what you are calling attent n to?

Mr. Scott: Yes, and the fact that it was in them w· h both quantities of oil.

Mr. Scott:

Q. 152. I hand you a photograph designated 15-2 and ask you to state what that represents?

A. This represents a photograph of froth, taken through the side of the vessel, magnified 25 times, the charge made up to contain two per cent of eucalyptus oil. The ore in this case was a mixture of chalcopyrite and silica.

Q. 153. Not a natural ore?

A. Not a natural ore, but a prepared sample, though, of course, both of these substances are natural in nature.

Q. 154. I understand. Does that froth extend to the top of the picture?

A. No.

Q. 155. Mark about where it goes to as near as you can discern?

A. About there.

Mr. Scott: I offer this photograph 15-2 in evidence.

Photograph admitted in evidence and marked Defendant's Exhibit No. 103.

2903 Q. 156. I hand you photograph 19-2 and ask you to describe that?

A. 19-2 is a photograph of the froth taken through the side of the vessel, magnified 25 times, the charge made up to contain one-tenth of one per cent of eucalyptus oil. The ore used is B. & S. ore. I have marked the top of the froth.

Q. 157. Are these markings supposed to be exact, or approximate?

A. Approximate.

Q. 158. Just the same as looking at that jar?

A. Yes, sir.

Mr. Scott: I offer 19-2 in evidence.

Photograph admitted in evidence and marked Defendant's Exhibit No. 104.

Q. 159. I hand you photograph marked 20-2 and ask you to describe that?

A. This is a photograph of froth, taken through the side of the vessel, magnified 25 times, with a charge made up to contain one-half of one per cent eucalyptus oil, the ore being B. & S. ore.

Q. 160. Butte & Superior?

A. Butte & Superior.

Mr. Scott: I offer this photograph in evidence, No. 20-2.

Photograph admitted in evidence and marked Defendant's Exhibit No. 105.

2904 Q. 161. I show you photograph No. 15-1. Please describe it.

A. That is a photograph of froth taken through the side of the vessel, the charge made up to contain 2% of eucalyptus oil and the ore in this case was a mixture of chalcopyrite and silica; magnified 225 times; and the froth extends beyond the picture.

Q. 162. At the top?

A. At the top.

Mr. Scott: I offer this photograph 15-1.

Said photograph was admitted in evidence marked Defendant's Exhibit No. 106.

Mr. Scott:

Q. 163. I hand you photograph 19-1 and ask you to describe it.

A. Photograph of froth through the side of the vessel with a charge made up to contain one-tenth of 1% eucalyptus oil magnified 225 times. The froth extends to the top of the vessel.

Mr. Scott: I offer photograph 19-1.

Said photograph was admitted in evidence marked Defendant's Exhibit No. 107.

Q. 164. I hand you photograph marked 20-1 and ask you to describe it.

A. 20-1 is a photograph of froth through the side of the vessel magnified 225 times; charge made up to contain one-half of 1% of eucalyptus oil, the ore being Butte & Superior ore. The froth extends beyond the top of the vessel.

2905 Q. 165. You notice in this picture the shiny spheres that I called your attention to in the other picture?

A. I do.

Mr. Scott: I offer this photograph 20-1.

Said photograph was admitted in evidence marked Defendant's Exhibit No. 108.

Mr. Scott:

Q. 166. I hand you photograph 19-3 and ask you to state what it is?

A. That is a top view of froth, the charge made up to contain one-tenth of 1% of eucalyptus oil.

Q. 167. What kind of a froth did that make?

A. It has a dead surface with a few bubbles on it, and not a very permanent froth, tender.

Mr. Scott: I offer this photograph 19-3.

Said photograph was admitted in evidence marked Defendant's Exhibit No. 109.

Mr. Scott:

Q. 168. I hand you photograph 20-3. Please describe it.

A. Top view of froth, the charge made up to contain one-half of one per cent. eucalyptus oil.

Q. 169. How does that froth compare with the one you last referred to?

A. That was one-tenth of one per cent. of eucalyptus?

Q. 170. Yes.

A. This is much more permanent and much larger bubbles; shows a bubbly surface.

Mr. Scott: I offer exhibit 20-3.

2906 Said photograph was admitted in evidence and marked Defendant's Exhibit No. 110.

Mr. Scott:

Q. 171. Please describe photograph 27-1.

A. 27-1 is a photograph of froth made according to the California Technical Journal of November, 1903, but mechanically agitated.

Q. 172. In what sort of an agitator?

A. In this bar mixing agitator, the same as these other oils agitated, and it had a magnification of 225 times and was taken through the side of the vessel; and the froth extended beyond the picture.

Q. 173. What was the ore that you used on this?

A. This is molybdenite ore.

Q. 174. And what quantity of oil?

A. The charge was made up of 15 grams molybdenite ore, 150 cc. of water at 50° C., 2.4 cc. smelter fuel oil equivalent to 2½ grams, and .4 cc. sulphuric acid, and the agitation was 30 seconds.

Mr. Scott: I offer photograph 27-1.

Said photograph was admitted in evidence marked Defendant's Exhibit No. 111.

Q. 175. I hand you this photograph——

Mr. Williams: I think I ought to move to strike out the statement that it was made according to the California Journal of Technology because it appears on the face of it that it was not.

The Witness: The charge is the same.

2907 Mr. Williams: I move to strike it out.

Mr. Scott: It don't make any difference how it is on the record.

The Court: It may stand. The motion will be denied. If it varies the court will not attach any importance to it.

Mr. Scott:

Q. 176. I hand you photograph 27-3 and ask you to describe it.

A. 27-3 is a photograph of froth.

Q. 177. The same froth that was shown in 27-1?

A. 27-1, top view, and the charge is the same, of course.

Q. 178. You said it was the same froth?

A. Yes, sir.

Mr. Scott: I offer this photograph 27-3.

Said photograph was admitted in evidence marked Defendant's Exhibit No. 112.

Mr. Scott:

Q. 179. Now, 27-2, photograph of what?

A. 27-2 is a photograph of the same froth.

Q. 180. Shown in 27-1?

A. Shown in 27-1 and 27-3, but taken through the side of the vessel and magnified 225 times.

Q. 181. Five diameters?

A. Five diameters.

Q. 182. The froth does not extend to the top of the mixture?

A. No, sir.

Mr. Scott: I offer photograph 27-2.

2908 Said photograph was admitted in evidence marked Defendant's Exhibit 113.

Mr. Scott:

Q. 183. Please describe photograph 28-2.

A. 28-2 is a photograph of froth through the side of the vessel magnified five diameters and the froth extends beyond the photograph. This was made, this froth was made in accordance with the California Journal of Technology, Technical Journal, of November, 1903, and the agitation was by shaking. It is a picture of froth similar to that.

Q. 184. It is in a vessel similar to the one used for this court demonstration?

A. Yes, shaken in what they call a mixing bottle, hand shaken. The charge was made up to 50 grams of molybdenite, 150 cc. of water, 2½ grams of smelter fuel oil and .4 cc. sulphuric acid.

Mr. Scott: I offer this photograph 28-2.

Said photograph was admitted in evidence marked Defendant's Exhibit 114.

Q. 185. Did you mention the temperature?

A. 50° C.

Q. 186. I hand you photograph 28-1 and ask you to describe it?

A. 28-1 is a photograph of the same froth as 28-2, only the magnification is 225 times, instead of 25 times—15 diameters. The froth extends beyond the photograph.

2909 Mr. Scott: I offer in evidence photograph 28-1.

Photograph admitted in evidence and marked Defendant's Exhibit 115.

Q. 187. I hand you photograph No. 23 and ask you to describe fully the procedure resulting in that photograph there?

A. Photograph No. 23 is a photograph of bubbles taken from froth from a charge containing one-tenth of one per cent. eucalyptus oil, Butte & Superior ore. The magnification is 20 diameters, or 400 times. These bubbles were separated from the froth, and placed in tubes containing clear water, and were photographed through those tubes.

Q. 188. Explain that a little more fully; I don't quite understand.

A. The bubbles were taken from the froth.

Q. 189. With a spoon or ladle or something?

A. With a glass tube put down in the froth and put your finger over the top and cut out a section of the froth, and that tube was put down in a basin of clear water again and the tube bent over sideways so as not to allow the clear water to enter the tube, and any bubbles that were broken, the sediment would fall to the bottom; then I took another tube of clear water and transferred some bubbles from that tube, under water, into this second tube, in order to get clear

water. Small corks were put in the end of that tube, and it was taken out and photographed.

Q. 190. And these bubbles were inside of that tube?

2910 A. Inside of the tube. You can sort of see the line of light of the tube, that line on the photograph.

Q. 191. And this other line, is that also the tube?

A. No, that is a sort of reflection of the side of the tube.

Q. 192. Everything we see here is inside the tube?

A. Everything is inside the tube.

Mr. Scott: I offer this photograph No. 23 in evidence.

Photograph admitted in evidence and marked Defendant's Exhibit 116.

Q. 193. Please describe photograph No. 24?

A. No. 24 is a photograph of bubbles made the same as photograph 23. The magnification is the same, 400 times, and the bubbles were taken from froth made from a charge containing one-half of one per cent. of eucalyptus oil.

Mr. Scott: I offer photograph 24 in evidence.

Photograph admitted in evidence and marked Defendant's Exhibit No. 117.

Q. 194. Please describe photograph No. 25?

A. Photograph 25 is a photograph of bubbles made in the same way, the magnification 400 times. The bubbles were taken from froth from a charge containing one-tenth of one per cent, oil mixture #3.

Mr. Scott: I offer photograph 25 in evidence.

Photograph admitted in evidence and marked Defendant's Exhibit 118.

2911 Q. 195. Photograph 26, please state what that is?

A. It is a photograph of bubbles made in the same way as the preceding; magnification 400 times. The bubbles were taken from a charge containing one-half of one per cent. of oil mixture #3.

Q. 196. This is the same oil mixture #3 that you previously referred to?

A. Yes, sir.

Q. 197. And the procedure here was the same as in these other pictures of bubbles?

A. The same.

Mr. Scott: I offer photograph 26 in evidence.

Photograph admitted in evidence and marked Defendant's Exhibit 119.

Mr. Williams: Did you state what the ore was in these last four?

The Witness: Butte & Superior ore, in all those bubbles.

Mr. Scott:

Q. 198. I hand you photograph 29.

A. It is a photograph of bubbles made in the same way, but the magnification is 256 times; 16 diameters. The bubbles are taken from froth from a charge containing one and a half per cent. of oil mixture. That is not oil mixture #3.

Q. 199. That is not #3, but the other oil mixture you described?

A. Yes, sir.

Mr. Scott: I offer photograph 29 in evidence.

2912 Photograph admitted in evidence and marked Defendant's Exhibit 120.

Q. 200. And the ore?

A. Butte & Superior.

Q. 201. I hand you photograph No. 30. Please describe it?

A. Photograph of bubbles made as in the preceding photograph. The magnification is 576 times, 24 diameters.

Q. 202. The oil?

A. The quantity of oil was one and a half per cent. oil mixture Butte & Superior ore.

Mr. Scott: I offer photograph 30 in evidence.

Photograph admitted in evidence and marked Defendant's Exhibit 121.

Q. 203. I hand you photograph No. 31; please describe it?

A. Photograph 31, photograph of bubbles made as in the preceding; magnification of 576 times. The bubble was taken from froth from a charge containing two per cent. eucalyptus oil, and the ore used was a mixture of silica and copper pyrite.

Mr. Scott: I offer in evidence photograph No. 31.

Photograph admitted in evidence and marked Defendant's Exhibit 122.

Q. 204. Please describe photograph No. 32?

2913 A. No. 32 is photograph of bubbles made as in the preceding; magnification 576 times. Bubble taken from a charge containing two per cent. eucalyptus oil. The ore used was a mixture of silica and copper pyrite.

Mr. Scott: I offer photograph No. 32 in evidence.

Photograph admitted in evidence and marked Defendant's Exhibit 123.

Q. 205. I take it that this photograph represents the apparatus used for making these froths?

A. Yes, that is the apparatus used in making these froths or most of them.

Mr. Scott: I offer this photograph last referred to by the witness.

Said photograph was admitted in evidence marked Defendant's Exhibit 124.

Q. 206. Now, in making these froths represented in these photographs, were a large number of each individual photograph made for the purpose of selecting or did you go right ahead from one to another, take them, we might say, as they came?

A. We repeated no froth except in the smaller percentages of oil, like one-tenth of 1%.

Q. 207. Are those the two that you referred to as being rather thin and meager?

A. Yes. I think these froths were repeated about three times; but in all others we went straight ahead and in no other case was a froth repeated.

2914 Q. 208. Simply photographed the first one you made with each quantity, with that exception?

A. Photographed the first one we made.

Q. 209. Now, if it wouldn't take too long, I think it would be good to state approximately the thickness of these different froths. You can designate them by your own symbols, that appear on the photographs.

Mr. Williams: You mean the height?

Mr. Scott: Thickness of the froth.

Mr. Williams: The height, is that what you mean by the term "thickness"?

Mr. Scott: It may be that your selection of language is more accurate. I think of it as "thickness." If more pleasing to you we will change the form of the question to "height."

A. I have the thickness of most of the froths and those that I didn't take, of course I omitted, but I thought the photographs themselves would speak for the depth of the froth, but I have most of them. Photograph marked No. 16——

Q. 210. That would apply to 16-1, 16-2 and 16-3, all?

A. Yes, 16-1 and 16-2 and 16-3. The froth of test 16 in the photographs 16-1, and -2 and -3, was one quarter of an inch thick. The froth from test No. 17, as indicated in the photographs 17-1, 17-2 and 17-3, the froth was one-half inch thick. In test No. 1, I have no measurement of the froth. Test No. 2, represented by photographs 1, 2, and 3, the froth was 11-16 inches thick. In test No. 3, represented by photographs 1, 2 and 3, the froth was three-

2915 quarters of an inch thick. In test No. 4, representing photographs 4-1, 4-2, and 4-3, the froth was 13/16 of an inch thick. In test No. 5, representing 5-1, 5-2 and 5-3, the froth was 11/16 of an inch thick. In test No. 8, representing photographs 8-1, 8-2 and 8-3, the froth was 11/16 inches thick. In test No. 9, representing photographs 1, 2 and 3, the froth was ⅜ of an inch thick, very large bubbles. In test No. 10, representing photographs 10-1, -2 and -3, the froth was 7/16 inches thick.

In test No. 11, representing photographs 1, 2 and 3, the froth was 6/16 or ⅜ inches thick. In test No. 12, representing photographs

12-1, 12-2 and 12-3, the froth was one-half inch thick. In test No. 13, representing photographs 13-1, -2 and -3, the froth was 6/16 inches thick.

Mr. Williams: Three-eighths?

A. Three-eighths. In test No. 14, representing photographs 1, 2 and 3, the froth was ⅜ inches thick. Test No. 15, representing 15-1, 15-2, the froth was three-quarters of an inch thick. Test No. 16, representing photographs 16-1, -2 and -3, the froth was 1¼ inches thick. Test 17, representing photographs 17-1, -2 and -3, the froth was ½ inch thick. Test No. 18, representing photographs No. 18-1, 18-2 and 18-3 the froth was an inch and a quarter thick. Test No. 19, representing photographs 19-1, 19-2 and 19-3 the froth was 5/16 of an inch thick. In test No. 20, representing photographs 20-1, 20-2 and 20-3, the froth was one-half inch thick.

Test No. 21, representing photographs 21-1, 21-2 and 21-3,
2916 the froth was 1¼ inches thick. In test No. 22, representing 22-1, 22-2 and 22-3, the froth was ⅝ inches thick. That is all of them.

Q. 211. In making these photographs have you any recollection or record of about the length of time that elapsed after the froth formed and before the photographic plate was exposed, that is, the intervening time between the formation of the froth and the exposure of the plate?

A. I have.

Q. 212. I don't know that it is necessary to go into detail for each picture, but I would like to know, in a general way, the average.

A. Here is test No. 2. The test—After stirring up the mixture we let it settle for about five minutes, then we took plate No. 2-1. Say this was 1.30. At 1.30 in the afternoon we took plate No. 2-1 and in that case we took two pictures, two plates of No. 2-1. The first was not long enough exposed. And then at 1.53 we took 2-2, and at 2.07 we took 2-3, so these photographs were taken in that order just as soon as practicable, we took them. First the froth is formed and allowed to stand from three to five minutes and then the photographs were taken, and were taken of course, 1, 2 and 3, as soon as possible with a certain interval, sometimes 5 minutes between the plates, sometimes 10, but never over 15. So the time lapsing between the forming of the froth and the last photograph would be less than an hour.

Q. 213. Somewhere near an hour possibly?

2917 A. Somewhere near an hour. But less than an hour.

Q. 214. Can you repeat a few typical instances of this, illustrate here in court with the apparatus you used?

A. I think I could.

Mr. Scott: If the court will indulge me a moment while we get the table in and the little bar mixer, we will show a few instances and if the other side decides any particular one of these that were performed we will be pleased to select the one they want. Otherwise we will pick out a few ourselves.

The Court: Where have you your supplies?

Mr. Scott: They are right upstairs in a room, and they have been told and they are all ready to carry them right in.

The Court: Very well, have them brought down promptly.

Mr. Scott:

Q. 215. What experiment do you propose to perform? Test No. 3.

A. Take four-tenths.

Q. 216. Of what?

A. The oil mixture.

Q. 217. With what ore?

A. Butte & Superior ore. We have a 60 gm. charge.

Q. 218. Now, Mr. Phillips, if you will describe the charge that you have placed in the jar?

A. The charge is made up of 60 gms. of Butte & Superior ore, and of 250 cc. of water at about 75° F.; also 2 drops of copper
2918 sulphate solution, which is equivalent to one-tenth of one pound of copper per ton of ore, and sulphuric acid was added equivalent to eight pounds of 60° Be. acid per ton of ore. I will now agitate the pulp before the addition of the oil for half a minute, so as to thoroughly mix the pulp through the water, which gives natural conditions.

(Witness turned on electric motor with small impeller attached.)

Mr. Williams:

Q. 219. At what rate of speed—how many revolutions does that impeller run?

A. I think it is run near 1,800, but I don't know.

Mr. Scott:

Q. 220. You may proceed, Mr. Phillips, and you may investigate that afterwards for Mr. Williams.

A. Now, in making a one-tenth of one per cent oil charge, it requires three drops of oil, so that four-tenths of one per cent would require 12 drops of oil. I will now agitate the charge again.

Q. 221. How long are you going to agitate the mixture?

A. I am going to agitate it eight minutes, which was the time I agitated the mixtures for the photographs.

Q. 222. Is it necessary to agitate it that long, do you think?

A. No, in some cases it is not.

Q. 223. You did that merely for uniformity, I suppose?

A. For uniformity. Any time between five and ten minutes, or sometimes less would do, but I did that for uniformity.

2919 A. Eight minutes agitation.

Q. 224. Now, Mr. Phillips, when that settles a little bit I would like to have you show it to the court. Have you an extra jar, Mr. Phillips, so we can keep that one while we make one with a larger quantity?

A. I have, yes sir.
Q. 225. Now, if you will go right ahead, Mr. Phillips.
A. In making another one——
Q. 226. (Interrupting.) I think the largest of this series was 1½% of the oil mixture, that is, photographs 5-1, 5-2 and 5-3?

Mr. Williams: 1.5.

Mr. Scott:

Q. 1.5% of the same oil mixture, that being .4 of a per cent that you have just made.

(The witness performs the experiment.)

Q. 227. That corresponds, does it, to photographs 5-1, 5-2 and 5-3?
A. Yes, sir.
Q. 228. I mean the charge?
A. This charge corresponds to photographs 5-1, 5-2 and 5-3, contains 60 grams of ore, 250 cc. of water, about 75° F., and sulphuric acid equivalent to 8 lbs. of 60° Be. acid to a ton of ore, and copper sulphate equivalent to one-tenth of one pound of copper per ton of ore. Agitated one-half minute before the oil was added and then added oil No. 3, 42 drops of oil mixture, No. 3, which is equivalent to 1½% of the ore added, and the amount of oil which is
2920 equivalent to one-tenth of 1% of the ore added. Instead of being exactly 3 drops was 2.8 drops by calculation in letting a large number of drops flow, so that makes—that 42 drops of oil equivalent to 1½% instead of 45 drops as would be in the other case. We agitated it eight minutes.

Mr. Scott: If there are any details you wanted, I would rather you would ask them and have them put on the record, Mr. Williams.
The Court: Any of the aides of any of you that desire to examine this of course can step up to the edge and do so.

Mr. Scott: Mr. Phillips, now for just one more of these, can you reproduce one, I think No. 18, with 25% of kerosene?

A. I think so, yes, sir.
Q. 229. 18-1, 18-2 and 18-3 are of a froth made with 25% of kerosene.
A. Yes, sir.
Q. 230. You haven't another one of those jars have you?
A. No, we will have to clean one of these jars.

Mr. Scott: After everyone has examined that we can throw one of those out.

Q. 231. Referring to this last demonstration, Mr. Phillips, with 1½% of that oil mixture, I understood you to say before that you adopted a uniform period of agitation of about eight minutes?
A. Yes, sir.
Q. 232. You did that simply for the purpose of comparison of the different froths?

2021 A. Yes.

Q. 233. Would you regard this one that you have just made as requiring that long agitation to make a froth?

A. I should not.

Q. 234. If it had been your aim to carry out the operation most efficiently would you have adhered to that eight minutes?

A. I would not.

Q. 235. You wanted to explain something about the oil mixture. In these photographs it is oil mixture, the second one you described?

A. Yes.

Q. 236. Not the No. 3, but the other one.

A. Not No. 3. And in this experiment only No. 3 was used.

Q. 237. That was because it was available or why?

A. That was because the other oil mixture was not available.

Mr. Scott: Will you empty one of those jars?

Mr. Williams: Empty the one with the 1½%. We would like to keep the one with the four-tenths per cent, although we would like to keep them both.

Mr. Scott: Take the 25% of kerosene test, No. 18, that will be all I will ask you to do.

Q. 238. Is this the same apparatus that you used in the test for the photographs?

A. This is the same apparatus that we used for a part of them and the other part I used an apparatus similar to that, but it is in Chicago.

2022 Mr. Williams: While we are waiting, have you any accurate data which will enable you to tell us the speed of rotation of that impeller when it is in operation?

Mr. Scott: Is it marked on the machine, Mr. Phillips? Sometimes they are.

Mr. Phillips: No, it does not give the speed.

Mr. Scott: And the diameter of the impeller is about three-quarters of an inch; is that right?

A. It is.

Q. 239. Is this going to be eight minutes, too?

A. No, a half minute now to mix it up.

Q. 240. But finally, I mean?

A. Agitated four minutes, the same as the last, the one in the photograph.

Q. 241. Make it the same then, four minutes.

—. —.

Q. 242. You may describe the charge you have put in the jar?

A. 60 gms. of Butte & Superior ore, 250 cc. of water, copper sulphate equivalent to one-tenth of a pound of copper per ton of ore; sulphuric acid equivalent to eight pounds of 60° Be. acid per ton of ore; and 25 per cent of kerosene.

Q. 243. Reckoned on the weight of the ore?

A. Reckoned on the weight of the ore. The kerosene is of the

specific gravity of .815, which would be equivalent to 18.4 cubic centimeters of oil. We will agitate this four minutes, as I have a record of four minutes for this mixture.

Mr. Williams: Do you know the Baume measurement of that kerosene?

2923 A. No, I do not.

(Agitating machine was run for four minutes.)

Mr. Williams: On behalf of the plaintiff I would like to test that apparatus that he used in court.

Mr. Scott: For speed, you mean?

Mr. Williams: We would like to do some of these things with it.

Mr. Scott: All right.

Q. 244. Do you find, Mr. Phillips, that this 25 per cent. of kerosene froth is made up of bubbles or not?

A. I do; I find it is made up of bubbles.

Q. 245. How about the one you made with one and a half per cent.—that is gone, but you remember it I guess. This one is the four-tenths of one per cent.

A. I think it was made up of bubbles also.

Cross-examination.

By Mr. Williams:

X Q. 246. In the three experiments you did in court you added sulphate of copper, was it?

A. I did.

X Q. 247. Did you do that in all the other experiments?

A. All the other experiments.

X Q. 248. So that every experiment that you have described here, in addition to what you describe in your testimony, you used sulphate of copper?

A. I think I did. I think I outlined my charge at the first

2924 and all these experiments were made practically on the same charge with the exception of the quantity of oil changing and the variety of oil, that the charge was 60 grams of ore, 250 cc. of water and enough copper sulphate to be equivalent to one-tenth of one pound of copper per ton of ore, and enough sulphuric acid to be equivalent to 8 pounds of 60° Be. sulphuric acid per ton of ore, and then I agitated that mixture for one-half a minute so as to thoroughly moisten the pulp so that we would have the condition in the test as would prevail in the mill, and then added the oil and proceeded to the agitation from the addition of the oil, not taking into account the half minute used in stirring up the pulp in the time of agitation.

X Q. 249. And in all these operations did you put the stirrer down to the bottom of the jar as you did those that were done in court?

A. I did. I operated the apparatus as I thought it was constructed to be operated. That is automatic, when you shove it down it makes contact; when you draw it up it disconnects.

X Q. 250. So that when the impeller enters the pulp it is rotating at its maximum speed and when it left the pulp it was rotating at its practically maximum speed?

A. I wouldn't say "maximum speed," but it was rotating on entering the pulp and on leaving the pulp.

X Q. 251. That is, the apparatus is so arranged that, as you push it down it commences and starts up?

A. It starts up.

X Q. 252. And as you lift it up it disconnects at some point?

2925 A. It does. Supposed to be automatic in action.

X Q. 253. That, of course, having been designed for the purpose of facilitating the mixing of drinks?

A. Yes, sir, it was.

X Q. 254. And the ores that you used today, what was that ore? You just describe it as Butte & Superior, but you didn't speak anything of its condition.

A. Butte & Superior, it was mill run No. 2. It contains 16% of zinc and 6% on an 80 mesh screen and 60% through a 200 mesh.

X Q. 255. And is it ore that has been through the water concentration process and the tailings of that process or is it a raw ore ground up?

A. I really can't answer on that. I do not know. Mill run No. 2—I don't know.

X Q. 256. You don't know it except by that name?

A. I know it by that name and I know it by that composition.

X Q. 257. Now, in several of these experiments you used something which you said was labeled "wood tar oil" and in others you have used something that was labeled "pine tar oil." What knowledge have you as to the oil itself?

A. I just took the—practically had no knowledge as to the composition of the oil itself. I didn't test the oil as to its composition, but I understood that in this case the wood tar oil and the pine tar oil are very nearly the same.

X Q. 258. What is the basis of that understanding?

2926 A. I think it would be some—I can't answer.

X Q. 259. Well, were you so informed?

A. I was so informed, and the odor, etc., would so indicate it.

X Q. 260. And who informed you?

A. It was sent to us in Chicago from the Butte & Superior Mining Company and the can was labeled "Pine Tar Oil."

X Q. 261. And the other one, the wood tar oil?

A. By the way, I have a sample of these oils, both the pine tar and the oil mixture.

X Q. 262. Let us have a specimen of each. Have you the oils that you used in these photographs? We already have had specimens of what you used in court. Will you let us have specimens of the other?

A. I can.

X Q. 263. As soon as your deposition is completed please hand them to Mr. Higgins. And this eucalyptus oil, where did that come from?

A. I purchased it at a drug store here in Butte.

X Q. 263½. And how was it designated?

A. Eucalyptus oil. They said it was California oil and it had a specific gravity of .925.

X Q. 264. And you have a specimen of that, of course?

A. I have a specimen of that.

X Q. 265. Do you know whether it was Eucalyptus Amygdalina?

A. I do not. They said it was California eucalyptus and not the Australian.

2927 X Q. 266. Now, you had a made-up ore or chalcopyrite and silica, can you let us have a specimen of that?

A. I can not, no sir.

X Q. 267. You did not give us a composition of that ore?

A. I just made that up for my personal experiment is all. It was made up of a very nearly pure chalcopyrite ground fine and just mixed with pure fine ground silica, about 6% each, and that was only made in a small quantity and I have no sample of that.

X Q. 268. Chalcopyrite is, of course, sulphide of copper?

A. Yes.

X Q. 269. And that is a metalliferous mineral?

A. Yes.

X Q. 270. And silica is one of the usual gangue?

A. One of the usual gangue.

X Q. 271. Now, the magnification which characterized your photographs numbered 1 and 2, were 15 diameters and five diameters?

A. Yes.

X Q. 272. Now you would characterize that as enlarged 15 times and enlarged 5 times, wouldn't you, in the ordinary course of events?

A. No, sir. That would be enlarged—the diameter of the enlargement would be according to the square of the diameters on account of the area, having two dimensions.

2928 X Q. 273. That is to say, comparing one man three feet high and another six feet high, the man six feet high would be four times as large as the man three feet high; is that right?

A. I would rather take another illustration, if I may. If you measure one side of this table as two feet, if the table is two feet square and you add two feet more on the side of the table, that table has 16 square feet, don't you see, instead of four. That is the area of the surface. So the magnification in that way increases it two diameters, which makes the area four times as big, which is the square of two. And so the magnification in this case would be the square of 15 and the square of 5.

X Q. 274. Well, if you had a mechanical drawing and you made all the dimensions one-half you would call it "half size," wouldn't you?

A. Call it half size.

X Q. 275. And then it would be one-fourth the area? Is that right?

A. It would be one-fourth area.

X Q. 276. The fact is that the dimensions were only magnified 15 and 5 times, the dimensions?

A. I hadn't thought about the other. In making drawings we are dealing with lines which only have one dimension, and when you make it half size you make the line half as long, you see, and this is making a line half size, and you divide the area by one-quarter, so one-half an inch has only one-quarter of the area that an inch has.

X Q. 277. I think that that is sufficiently clear, but as a matter of fact all of the dimensions in that number one are increased fifteen times?

2929 A. All the linear dimensions, yes, but the areas are increased 225 times.

X Q. 278. And all linear dimensions in the others are increased five times, although the areas are increased 25 times, the square of five?

A. Yes, sir.

X Q. 279. I suppose you did this work under the direction of some one?

A. Well, no, sir, I did the work myself. I made all the tests and measurements as I did here, and I had the photographer right there with me, and he made the photographs under my direction, and I marked the plates in the dark room as soon as they were exposed, and he developed them and did the printing.

X Q. 280. I thought you said M. Dosenbach helped you?

A. No, sir; I don't remember saying so.

X Q. 281. Who laid out the plan of operation for you?

A. Mr. Hoskins and I together talked over the plans.

X Q. 282. You received the plans, did you?

A. I suppose Mr. Hoskins did—as I understand it, I think the idea is Mr. Hoskins'. He did not receive any plans of these tests at all.

X Q. 283. As far as you know you did them along the line of Mr. Hoskins' plan?

A. Yes, sir.

X Q. 284. What was the highest percentage that you used of the wood tar oil or the pine tar oil?

2930 A. I think two per cent.

X Q. 285. And the highest percentage you used of those oil mixtures?

A. One and a half per cent.

X Q. 286. Where did you get the kerosene from that you used in your experiments?

A. I got it upstairs in the laboratory in a bottle.

X Q. 287. I mean when you photographed?

A. At the same place.

X Q. 288. It was sent to you?

A. No, sir, it was in the laboratory in this building, upstairs.

X Q. 289. When you made the photographs?

A. Yes, sir.

X Q. 290. Were the photographs made in this building?

A. Some of them. I think it is the same kerosene that I used in the experiment here—out of the same bottle.

X Q. 291. This is the kerosene that was in the laboratory of the defendant; it was in the laboratory of the defendant that you got it?

A. In this laboratory in this building, yes; but whether it was in their other laboratory I don't know.

Mr. Williams: That is all, unless, after testing the apparatus we find that we may want to ask a few more questions for further enlightenment.

2931 Redirect examination.

By Mr. Scott:

R. Q. 292. Do you think, Mr. Phillips, that it makes any difference whether this agitator is running at the moment it enters the pulp and at the moment it leaves the pulp?

A. I don't think it does; I think it makes no difference.

R. Q. 293. If you are requested to, are you willing to repeat these experiments and stop the agitator before it leaves the pulp and not start it until after it enters the pulp?

A. I am.

Witness excused.

FRANK R. WICKS, recalled, testified as follows:

Direct examination.

By Mr. Scott:

Q. 1. Mr. Wicks, you have informed me that there were some errors in the tabulation which you produced and which is in evidence as exhibit 28, "Chino Copper Company, record of flotation operations for the treatment of slime vanner tailings."

A. Yes, sir.

Q. 2. You may state what these errors are, but before you do that and give the corrections, you may explain how they occurred?

2932 A. The errors were made by the clerical department in making up the statement, and they were not discovered until after we checked them over here, so that we went through and recompiled the entire statement. I did that personally.

Q. 3. You had the figures to make the corrections from?

A. Yes; we brought them with us.

Q. 4. What was the nature of the first error that you refer to?

A. The first error here is in the first column, under "weight, dry tons"; the figure on the fourth line, 8065, was added in the total twice, so that that changes the total of that column by the amount of 8065.

Q. 5. What is the correct total then?

A. 2,064,070 is the correct total.

Q. 6. And the next particular in which there is an erroneous statement here?

A. In the next column, under the heading of "average daily tonnage" we made one or two changes; for instance, the first figure was given as 410, and we figured 573.

Q. 7. What did you figure that from?

A. The number of days shown there, 15 days, and the total weight treated during the time was 8600 tons.

Q. 8. It was simply a question of division?

A. Yes, sir.

Q. 9. What next?

A. Do you wish me to enumerate each of the changes as I go down?

2933 Q. 10. You can do it in the way that is most convenient for you?

A. There were a great many of these figures, that did not enter into the original record; will it be necessary to repeat each one of them?

Q. 11. Well, you can state what the corrections are in the exhibits?

A. In the same column, the fourth line, 979 should be 1251.

Q. 12. How did that error occur?

A. In the same manner; it was an error in taking the number of days.

Q. 13. An error in computation?

A. Yes, sir. The average daily tonnage shown for the year 1915, reported as 1179, should have been 1812. All of these errors occur in taking the wrong number of days to figure against; they are really immaterial. 3,048 shown for the second quarter of 1916 should have been 3,081; and the average of our operations to date, as shown at the bottom of that column, 2999, should have been 3127.

Q. 14. The difference in the average arising from the change in the figures you have mentioned?

A. Yes, sir. Now, the next column "assay per cent copper." When we were making the corrections we thought best to change the averages from ordinary numerical averages to calculated averages, because the calculated averages are more nearly accurate.

Q. 15. Explain the difference between them?

2934 A. For instance, the average of any one quarter or for one year, or for any actual part of the time, sometimes it is accurate enough if we arrive at the average arithmetically, if we simply add up the column and divide by the number of items. But that is not always quite accurate, because, for instance, we might have 100 tons of two per cent ore and ten tons of one per cent ore, so we could not very well add up the one per cent and the two per cent and take a numerical average of one and a half per cent, but we can take the calculated average, taking into consideration the totals, which is more accurate.

Q. 16. And you changed that column in the assay per cent of copper in the manner you have indicated?

A. Yes, sir.

Q. 17. Does it change the average?

A. No, sir; it changes the average for 1915, which was shown as .798, and it is now changed to .78. In the first quarter of 1916, which is the figure following that, .88 is changed to .89. The third quarter of 1916, .86 is changed to .82, and the average for the year 1916 is changed from .84 to .83, and the average for the first quarter of 1917, the last figure in the column, is changed from .75 to .74. The average of the entire column is changed from .814 to .804.

Now, Mr. Williams has called attention to certain errors in the tonnage in the first column, which is headed "flotation concentrates, weight, dry tons." I find that in making that up that in some way they got the tonnage of the rough concentrate during that
2935 period, instead of the tonnage of the finished concentrate—or at least during a portion of the period, so that we are changing the total tonnage for the fourth quarter of 1915 from 20,842 to 2,874. The figure following that, which depends on that, is changed from 23,285 to 4,889; and the next figure, 3915 is changed to 2952, which applies to the first quarter of 1916. The figure shown for the fourth quarter of 1915, 3668 is changed to 3676. Of course the year is changed from 13,945 to 12,990, and the total of the column is changed from 41,062 to 21,713.

Now, in the next column we made a few minor changes, not particularly important, but I will enumerate them. For the period July 13th to 23rd, inclusive, the figure shown as the assay per cent copper of flotation concentrate 4.90, is changed to 4.23. The third quarter average is changed from 16.93 to 16.99. Those averages are being changed, as I said, because of using the geometrical or calculated averages instead of the arithmetical averages. The first figure of the fourth quarter is changed from 23.08 to 23.43; the next figure is changed from 22.06 to 19.95.

A. For the first quarter of 1916, 21.27 is changed to 21.13. The next figure, 27.03 to 27.35. The next one, 28.07 to 29.64. The next one 29.53 is changed to 29.64. The average for the year 1916 is changed from 26.48 to 26.47. The last figure in the column, which is the average for the first quarter of 1917, is changed from 28.63 to 27.47 and the
2936 average for the entire column is changed from 24.175 to 25.352. You will notice that there are no changes in the dates in which the special ones were made because that was not affected. Flotation tailings, assay per cent. copper for the third quarter is changed from .47 to .48. The next figure from .54 to .56, and the next figure from .54 to .56 which is the same. The next one, .67 is changed to .68. The average for the column is changed from .539 to .543. Now, there was just one more column, "Flotation tailings per cent. indicated recovery." The average recovery for May 1 to 25 is given as 23.01, is changed to 21.40. For the period July 13 to 23, 30.37 is changed to 30.73. The next figure, 35.35 is changed to 34.88. The next one from 35.72 in changed to 28.81, and the average for the year 1915 is changed from 33.14 to 29.32. The first quarter of 1916 is changed from 25.92 to 24.25. The next one, 33.43, changed to 34.36. The next one, 35.94 to 35.68. The next one, 37.59

is changed to 37.39, and the average for the year 1916 is changed from 33.27 to 33.05. The average for the first quarter of 1917 is changed from 37.87 to 37.84, and the average of the column is changed from 34.553 to 33.139. Just one other little change in the quantity of oil used during the year 1915 given as 1.04 pounds per ton, is changed to 1.06 pounds per ton. I believe that covers all the changes made.

Q. 18. These changes in the column headed "Percentage of Indicated Recovery," how did they arise?

2937 A. Those are also due to the changing from the arithmetical to the the calculated average.

Q. 19. And the errors that you pointed out in the column "Assay Per Cent. Copper"?

A. Of flotation tailings?

Q. 20. Yes.

A. The same is true of that.

Q. 21. The change from the arithmetical to the calculated average?

A. Yes, sir.

Q. 22. I think Mr. Williams asked you when you were on the stand before to compile for April 4, the total amount of oil percentage, or the total amount of oil relative to the total tonnage that was in the ore including both circulating and original oil, and ore. That was my understanding of this question?

A. Yes. I have my figures here on that. I will read them. They will afford an explanation of the manner in which that is compiled. The dry tons of initial feed treated during that 24 hour run on April 4th was 3,250 as shown on this statement. The measurements of the circulating load show 8,053 wet tons of material circulating in the 24 hours. The solids in that circulating load were found to be 6.23%. You will remember that I gave you a figure of 6.00 and 6.5% solids for the average of the two taking into consideration the difference in tonnage, figures to be 6.23%. They therefore calculate that there were 502 dry tons in the circulating load. This amount, added to the initial feed would be 3,782 tons, dry tons of total feed in the

2938 plant. We added a total amount of oil of 26,330 pounds. This is equivalent to 8.1 pounds on the initial feed. Or, if it is figured the total feed would be equivalent to 7.0 pounds per ton.

Now, the total pounds of oil circulating, which is determined by analyzing the wet circulating load, was 10,495 pounds of oil circulating during the 24 hours. That circulating oil is equivalent to 3.20 pounds per ton of initial feed, or it is equivalent to 20.0 pounds per ton of the circulating feed, or figured against the total feed, that is, the initial feed plus the circulating feed, is equivalent to 2.8 pounds. Now, the total oil then, per ton, of initial feed is 113 pounds and the total oil if it is figured against the total feed, would be 9.8 pounds. Now, I presume that that statement might be taken one way or another. The headings are not particularly lengthy and it might possibly lead to some confusion; but with that statement that ought to make it clear.

Q. 23. Taking into account, Mr. Wicks, the circulating oil with the amount stated of initial oil pounds per ton for March 13, 14, 21 and

27, represents more ore than the total amount of oil of all kinds per ton of material in the machine, of all kinds, both circulating and original?

A. Well, if we figure the total oil against the total feed on those days I am quite positive that the pounds of total oil per ton of total feed would have been considerably greater than that, because we find that the amount of oil in the circulating load per ton of the material in the circulating load is equivalent to two and a half times the
2939 figure which would represent the initial oil, per initial ton. That is a little hard to figure, but if it is not clear, I can explain it further.

Q. 24. You mean that the middlings carry a considerably greater proportion of oil than is actually supplied to the initial feed?

A. Yes, sir. That ratio that we have established from what tests we have made would apply, for example on the 13th of March, on which day we had 24 pounds of initial oil per ton of actual feed; we would have, for every ton of circulating load on that day, we would have from 48 to 60 pounds of oil per ton of circulating feed. Do you see?

Q. 25. In other words, the circulating feed carried more oil than is supplied to the original feed?

A. Yes, sir.

Q. 26. And that excess brings the total average up?

A. Yes, sir.

Q. 27. I think you were asked when on the stand before to give some information as to the operations on November 18th, 19th and 20th of 1916, which are set forth on exhibit 26, "Chino Copper Company, Record of Flotation Operations and Retreatment of Vanner Concentrates"?

A. Yes, sir, I have some figures here on that. On November 18th, 19th and 20th Mr. Williams asked me to give him the exact percentages of different kinds of oil used on those days. Now, the original records show that on November 18th we used 3,985 pounds of Barrett's No. 4 creosote and 225 pounds of Jones oil, no other oil
2940 was used. On November 19th, we used 4,025 pounds of Barrett's No. 4 creosote and 200 pounds of Jones oil, and no other oil was used. On November 20th we used 4,500 pounds of Barrett's No. 4 creosote and 330 pounds of Jones oil. You also asked me in connection with that to give you the percentage of the oils used on the 25th of November, which was a day during which we used 26.14 pounds of oil per ton of initial feed. On that day we used 4,570 pounds of Barrett's No. 4 creosote and 240 pounds of Jones oil. On the 18th, 19th and 25th the proportion was approximately 95% of the Barrett's No. 4 creosote and 5% of the Jones oil. On the 20th the proportion was 93% of Barrett's and 7% of Jones.

Q. 28. Did you state how the errors arose in the column "Flotation Concentrate Weights, Dry Tons" in this exhibit 28?

A. Yes, sir. In making that up, they included a tonnage of rough concentrate instead of a tonnage of finished concentrate.

Q. 29. Have you a corrected table embodying these corrections which you have pointed out?

A. Yes, sir.

Q. 30. Of which you have extra copies?

A. Yes, sir. I would say that Mr. Wiser and I compiled this statement, each of us performing practically all of the operations in order that we would both satisfy ourselves that it was correct, but Mr. Wiser signed the statements because he signed the first copy or the original statement.

2941 Q. 31. The one that was put in evidence before?

A. Yes, sir.

Q. 32. But you have calculated these corrections from original data, I understand?

A. Yes, sir.

Mr. Scott: Then I will offer this corrected statement. Any objections?

Mr. Garrison: The same objection; our standing objection only.

The statement was admitted in evidence and marked Defendant's Exhibit 125.

Mr. Scott: That will be all. Have you any cross-examination?

Mr. Williams: Just one or two questions.

Cross-examination.

By Mr. Williams:

X Q. 33. Mr. Wicks, in your table of "Flotation Operations on Retreatment of Slime Vanner Tailings" under the heading of January 7, 1917, you state the assay per cent. of copper to be 22.47. My calculators estimate, upon figures you have given us, the amount of copper should be 5.13. The discrepancy is so large that I will ask you to give it careful consideration, and, down that column I may say that every item of calculated assay is variant from your given assay, upon the figures given, although that is the most striking one.

2942 A. I am not certain that I have that one written up. I have no figures here that will enable me to give you that.

X Q. 34. Well, with that suggestion of criticism on my part will you do as you did before, go over your figures very carefully?

A. I will have to send for the figures on that.

X Q. 35. These are the computations that come from figures that you gave as to the recovery, including heads and tails and the discrepancy is so large that I think it ought to be explained.

A. All right.

X Q. 36. Now, I asked you to furnish working drawings of the Janney machine. Are you able to do that now?

A. I made a request for them, but I didn't get them, yet.

Mr. Williams: That is all for the present. I have got to go over these recalculations and will just postpone further cross examination.

Mr. Scott: Our next witness will be Professor Taggart.

Mr. Williams: I assume you do not care to put Dr. Sadtler back?

Mr. Scott: I thought we would get all of the data that he is supposed to comment on, so as not to break his testimony again, as I was obliged to do before, in order to fill up the time.

2943 Prof. ARTHUR FAY TAGGART, a witness called on behalf of the defendant being first duly sworn testified as follows:

Direct examination.

By Mr. Scott:

Q. 1. Professor Taggart will you state your full name, please?

A. Arthur Fay Taggart.

Q. 2. Will you state your education and experience in relation to mining and metallurgical matters?

A. I went to college, Stanford University, and hold a degree of Bachelor of Arts and the degree of Engineer of Mines from that university. Since graduation I have worked in various mills and done some examination work in foreign countires and for the last five years I have been instructor and assistant professor of mining engineering at Yale University and a consulting engineer associated with J. F. McClelland and L. W. Bahney at the same address.

Q. 3. Have you any connection at the present time with mining operations or mining interests?

A. None at all other than as consultant.

Q. 4. And how did you happen to become interested in flotation?

A. As a matter of academic interest rather than any other. It is more or less incumbent upon a university to keep abreast of the times, and when the discussion of flotation and the use of flotation became broad, it was immediately up to us to try to find out

2944 what we could about the subject.

Q. 5. Were there any formal actions or conferences in the university on the subject?

A. The question of flotation seems to involve considerably more physics than is included in the working knowledge of the average mining engineer and we thought in conference in the Mining Department that it would be well to get in touch with the Physics Department and try to get the Physics Department to supply the requisite knowledge of physical phenomena, while the mining department could supply the questions and point out the particular lines of research and that then a member of the physics department and myself could work together along this particular line.

Q. 6. Did you mention at the beginning of your testimony of your having had practical mining and metallurgical training?

A. I have had.

Q. 7. You stated the facts as to your practical experience, did you?

A. Yes, I did.

Q. 8. You did not state where, did you?

A. I have worked in the mill of the Nevada Consolidated Mining Company at McGill, Nevada, and in the mill of the Montgomery

Shoshone Mining Company at Rhyolite, Nevada. I worked in both those mills as an operator of various kinds of metallurgical machinery, and I have assisted, with my associates, in the designing of three or four kinds of metallurgical plants, that work con-
2945 suming a considerable portion of my time for the last three or four years.

Q. 9. Through how long a period has your investigation of the flotation process extended?

A. About two years.

Q. 10. Have you come to any conclusion as to what are the essentials in this so-called agitation-froth flotation process?

A. First, we must agitate and aerate a pulp with some reagents which will absorb at the gas-liquid and at the solid-liquid surfaces, and after such agitation and aeration the pulp should be allowed to pass to some point, a box or cell, where the bubbles which have been beaten into or passed through the froth can rise to the surface of the mixture, carrying with them the load of solid matter, which ordinarily is the sulphide that it is desired to separate. The ordinary reagents used are oils or some fatty substance, acids or alkalis. The ores usually treated are those consisting of a sulphide or occasionally some other materials of adamantine or metallic luster, and a gangue consisting of some rock not having the adamantine or metallic luster, and ordinarily valueless.

Q. 11. Have you come to any conclusion as to what the function of the oil is in the agitation froth flotation process?

A. The oil seems to have two functions; first, to aid in the formation of a stable froth; second, to act as a selective agent for the separation of the sulphide from the worthless rock—and I hope that throughout the subsequent discussion the word sulphide will
2946 be taken to include such other few minerals as there are, which are not sulphides, and which yet are amenable to concentration by flotation. Graphite is one which is obviously not sulphide, and yet is so amenable.

Q. 12. Can you state in what way oil aids in the formation of a stable froth?

A. It acts in three ways I believe. It acts first, to reduce the surface tension of the water with which the ore is mixed. It also, by adsorbing or concentrating at the surface of the bubbles, within the pulp, forms a film, at the contact of which with the water in the pulp, there is formed an interface which is markedly more viscous than either the oil or the water or the mixture of the two. Finally, the oil will vary in concentration in the bubble film in such a way as to allow the bubble film to vary its strength of resistance to external forces. In those three ways oil aids in the production of a stable froth.

Q. 13. Is there any simple experiment by which you could show, visually, that the oil does in fact reduce the surface tension?

A. There is. Would you like me to perform it now?

Q. 14. There will be time enough, won't there; it will only take a few minutes?

A. I think so, yes.

Q. 15. I will have the things gotten for you. Mr. Dosenbach knows where they are, does he?

A. Yes, Mr. Dosenbach knows.

2947 Q. 16. You might describe this experiment in advance?

A. I wonder if I might have a blackboard. I am rather accustomed to working with a blackboard.

Q. 17. There is one here; you may step to the blackboard.

A. (Drawing.) This particular experiment that I am about to perform to show the reduction in surface tension by oil is to float a match on the surface of a body of water in a pan. The match will then appear in some such position as this (drawing). As soon as the water in the pan comes to rest, the match will be held stationary under the influence of the forces of surface tension, which are equal, and which act equally in all directions, and which I may represent by these arrows. Now, if on the surface of that pan we place a drop of oil at one side of the match—say, there—then the match will jump over against the side of the pan, away from the point at which the drop of oil is placed. The explanation of that particular phenomenon is, of course, the reduction of the surface tension of the water, due to the oil film upon it, and we find some such condition as this: If I represent this as the drop of oil, and the immediate sphere of action of the oil that spreads over the water by this curved line, then the force on this side, the surface tension, will be reduced in some such fashion as that, (drawing) while those on this side will momentarily remain as before, and of course the match will be pulled away by the preponderance of the surface force on the side away from the oil.

2948 Q. 18. Is there any simple or graphic way that you can state, just roughly, what this surface tension is?

A. It is a pull. You can consider the surface of the water itself as a stretched skin, similar to a sheet of elastic stretched over a ring or the head of a drum. Either of those things, while they are solid, are in the same state of tension, exactly, as the surface of any body of water. If we take the particular case of the elastic film and carry the parallel further, if you should place the match on the rubber film and cut the film at one side and thus reduce the tension on that side, of course the film would spring back toward the other side and carry the match with it. You would have there an exact parallel between the surface tension of water and the tension of that elastic film, pulling the match away in both cases from the place where it originally was, due to the preponderance of force on the side away from that where the tension was reduced.

Mr. Williams: Will the professor furnish us drawings of the diagrams that he is making on the board?

Q. 19. I understand you are going to furnish little drawings the same as those you are putting on the blackboard?

A. I will, yes.

(The witness performed the experiment.)

Whereupon an adjournment was taken until Wednesday, April 25th, 1917, at 10:00 a. m.

2949 Wednesday, April 25, 1917.

MR. TAGGART on the stand.

Direct examination resumed.

By Mr. Scott:

Q. 20. You have referred, Prof. Taggart, to the formation of a viscous film at the junction of the oil and water. Can you show this by an experiment?

A. I can.

Q. 21. I will ask you to do so.

A. May I first explain by blackboard drawings what I expect to have happen?

Q. 22. Certainly.

A. Now, for the purpose of showing that at the interfacial boundary between oil and water there forms a viscous film, I am going to take a beaker and place in it, at the bottom, some water, and for the purpose of making the phenomena to be observed more easily visible, I am going to color that water with red ink, and I will represent it here as so colored. After having placed the water colored with red ink in the bottom of the beaker, I will place above it a layer of oil, which, again, for the purpose of making the phenomena more easily observed, will be colorless. Then by means of a medicine dropper inserted with the point below the oil-water interface, I will release below the oil-water interface, some bubbles. The bubbles in rising will first strike the surface between the oil and water, and will drag that surface up in this fashion. (Figure 2)

2950 That particular phenomenon is indicative of the presence at the interface of a film which is considerably more viscous than the body of the water or the body of the oil; it will indicate more viscosity than the water, because it will have passed through the water freely until it strikes that film, and having been released from that film, as it will be later, it will pass through the oil freely, indicating, then, a greater viscosity at this interface than is present in either the colored water or oil.

(Drawing Figure 3). I will omit the medicine dropper, which, of course, will be present. Then after the bubbles have broken away through the viscous film of the interface, it will appear like this; then rising through the oil there will be the air at the center, surrounded by a film of considerable thickness of the colored water. That will pass up through the oil and arrive at the surface of the oil in some such condition as that, and when closely observed, some of these bubbles—all of them will not act in the same way—will show a red color at the surface of the oil, indicating that the film is still around the bubble. The film will have dragged down sufficiently when the bubble reaches the surface, so that the red color in some instances cannot be observed, and in those particular bubbles the condition will be this. (Figure 4.)

Now, eventually both of those water coatings will drop from the

bubbles and they will fall back through the oil in this cup-shaped form, and there will be apparent at the edges of the cup—the
2951 rim of the cup—some of the thin films that look almost like a red tissue paper. Now, it is the fact that the water, falling through the oil, preserves its shape rather than taking a spherical shape as would be ordinarily the case of a drop of water falling through a fluid such as air. That is an indication of the high viscosity of the film at the boundary between the water and the oil. According to the law that a mass will tend to a condition of least potential energy, and due to the further fact that a sphere is the solid whose surface is the least for its volume, and to the fact that with the least surface the particle of water will present the least potential energy, the particle should, if allowed to follow its tendency, assume a spherical shape. Now, the force of the surface tension that would tend to cause it to assume a spherical form, is overcome, in this instance, by the high viscosity of the film at the interface between the water and the oil, and you get, consequently, this shape, which is absolutely unnatural for a particle of water to assume, if it were not under conditions, as it is, where the viscosity of the surface is so great as to overcome the force of surface tension, tending to make it a sphere.

There will also be present in this mass of oil above the bubbles, if the bubbles are blown in with sufficient rapidity to agitate the surface of the interfacial film, particles of water shaped something like this, tadpole shape, as these are, again due to the excess of viscosity—the excess force of the viscosity of this interfacial film over the force of the surface tension of the water itself. (Figure 5.)

2952 Now, I will perform the experiment.

Q. 23. Just state, professor, what you do as you go along and the stenographer will put it down?

A. First I poured the water into the beaker and inserted the bubble blower. Then I placed red ink in the beaker and then poured on to the surface of the ink a layer of oil, kerosene oil being used.

Q. 24. About how thick is the water layer and the oil layer?

A. The layer of water and the layer of oil are approximately an inch each in thickness. Now, first you will observe the way in which the interface pulls up as the air is inserted, indicating there the viscous film at the interface. As you will have observed, very quickly, the fact that some of the bubbles as they appear at the surface are coated with the red water. The holding of this red water layer at the surface is a momentary thing, merely. Then as the water falls back from the surface the cup shaped or bowl shaped drops of water may be observed. Finally if I blow the air through rapidly, the little tadpole shaped particles will, I think, be noticed.

Q. 25. What are you trying to show now?

A. These bowl shaped drops of red water.

Q. 26. I don't know that the court gets a clear view of it. It is like a little shred of something falling. You will have to look very closely to see it.

The Court: Let me play with it.

The Witness: If you release the bubbles near the center you get better results.

2953 The Court: You operate it, that is your trade, not mine. I see the distorted shape of the bubbles as they drop back.

The Witness: That is the thing I wished you to see.

The Court: I have observed that.

The Witness: The cup shaped bubbles, and the fact that there is a little fringe, as it were, hanging back around the cup where the film has been drawn out to a greater extent at the very edge of the bubbles.

The Court: As they come to the top they break in two, part of it go back?

A. Yes, the water goes back and the air stays up.

The Court: That which goes back is water entirely?

A. Oh, yes. It can be none other, because the water is colored and the oil is uncolored.

The Court: I mean there is no air inside of that that goes back

A. No, no, there is no air.

Mr. Scott: How would that be, doctor, if done in a jar about a foot deep? Would we have more time to look at it as it was dropping? Would that be any better?

A. I think it would be more visible.

The Court: I think I see what he is trying to illustrate.

Mr. Williams: I would ask if your honor has seen the thing that is pictured there?

2954 The Court: No, I have not seen the distinct cup shape, it seems to me, going back. It appears to be in rather a globular form, some of these, going back.

The Witness: Yes.

The Court: Are these solely water or is there air inside?

A. Those are solely water, unless you can see an occasional air drop. (Here the witness agitates the solution rapidly with the dropper.) Now, you see there are a great many of these small water globules at the top and no air there except occasionally an entrapped particle.

The Court: Your idea is as it comes up it is air and water there and the air stops at the top?

A. Yes, and the water falls back; and, due to the fact that the water is in contact with the oil, there is sufficient viscosity at the interface to overcome the surface tension. The experiment is, of course, to indicate the high viscosity of the film at the interface between the oil and the water.

The Court: I observe that lifting feature. I can't say that I observe as broadly as you make it there the saucer shape, but I can observe it goes back in a flattened form. Don't you think that these are all dropping back with a convex upper surface?

A. No, sir. The larger ones are but the smaller ones are not. There, did you see that one?

The Court: Yes, rather flattened out, as I say. I have observed that feature.

2955 A. And that one?

The Court: Yes, that is flattened.

The witness: Of course, they will assume a spherical surface as they go down.

The Court: I think I understand.

Mr. Scott: You have drawn it in section on the blackboard?

A. Yes.

The Court: I understand what you mean.

The Witness: The edges come up just as though they were tissue paper. As you get them larger the surface tension being a function of the area, is sufficient to overcome the viscosity. The smaller bubbles are more like the conditions in the flotation process where everything is beaten very fine. Then the force of viscosity is great enough to overcome the surface force.

Mr. Scott:

Q. 27. Can you show by some experiment, other than by actual flotation operation, the fact that oil tends to select a sulphide mineral in the presence of water and that water tends to select gangue in the presence of oil? Or, in other words, can you show that in the presence of water oil will selectively adhere to a sulphide particle in the presence of a gangue particle?

A. Yes. (Witness performing an experiment.) Now, I have placed in this cell a piece of galena and a piece of quartz and covered them so that the galena is about one-half inch and the quartz
2956 about an inch below the surface of the water. I am going to drop onto the surface of the water some drops of wood creosote, and some of the drops will, due to their momentum and the lessening of the surface tension of the water, fall through onto the respective minerals, and we will find that on the galena the oil tends to spread out over the surface, while on the quartz it tends to draw up into a globule and remain in that state. Now, if I may draw on the blackboard so it will be a little easier to see.

Mr. Scott: I should like the record to show that we will have these sketches reproduced on paper for the record, these blackboard sketches.

Mr. Kremer: That will be satisfactory to you, Mr. Williams? We will erase these and draw them on paper and submit them to you.

Mr. Williams: Yes.

I think that the phenomena that we observed in the cells are presented in the sketch here (diagram 3). The drops of oil on the surface of the galena tend to spread out and replace the water at that surface. The drops of oil on the surface of the quartz tend to draw up from it in the shape of a sphere. In other words, the water tends to push in under the oil at the quartz surface and replace the oil, so that we have then an instance of the selective action of the oil on galena or sulphide in the presence of water, and the selective action of the water on quartz or other gangue minerals in the pres-
2957 ence of oil. It is, of course, this selection which is depended upon in the flotation process for the separation of the valuable sulphide minerals from the worthless rock.

By Mr. Williams:

Q. 28. Now, professor, I observe that the oil on the quartz is a globule which is quite perceptibly flattened out at its lower end, and, although it is not of very much importance, there is no doubt that what you have drawn there is slightly different from what that shows.

A. That is right; I will bring that down a little bit. (Drawing.) I believe that would be rather more in line with the phenomenon.

Mr. Scott: I now offer diagram No. 3 just made by the witness in evidence.

Diagram No. 3 admitted in evidence without objection marked Defendant's Exhibit No. 126.

Mr. Scott:

Q. 29. You stated that the oil assists in the formation of a stable froth, and have shown by experiments the functions of the oil in such formation. What other conditions must prevail in order that the froth may be stable and persistent?

A. It must carry a load of finely divided solid matter.

Q. 30. What is the effect of the solid matter?

A. It is to increase the viscosity of the film very markedly.

Q. 31. Can you show that also by a simple experiment,
2958 the increase of viscosity due to the presence of solid matter?

A. Yes. (Drawing.) I will attempt four different experiments here to prove that it is the presence of solid matter which causes the formation of a stable and persistent froth. In the first place, if this represents the surface of a body of water, and I have floated on that body of water a little raft, like this,—this being a part of a match stick, and this being part of a match stick, and this a needle—(The reason that I am using this peculiar apparatus is that I want to be able to move the raft by means of a magnet, without touching the surface). Then, if I float over here a chip, I will be able to turn that raft on the surface of the water without turning the chip, showing that there is no greater viscosity in the interference between the water and the gas. That will be experiment No. 1 (Figure 1).

In experiment No. 2 I will use the same device, except that in this particular case I will dust upon the surface some finely divided ore (Figure 2) and then when this raft is moved by means of the magnet, it will be seen that the chip moves with the raft. In other words, that this surface is acting as though it were a solid. The viscosity has been so greatly increased by the addition of the solid matter to the interfacial film.

(Figure 3.) Now, in experiment 3 I will take the raft and the chip and will place on the surface of the water a drop of oil
2959 sufficient to contaminate the water and lower the surface tension. At the interface between the oil and the water, there will be a viscous film which is characteristic of such an interface, and it will be seen that when I turn the raft, that the chip itself will not turn. By ordinary visual methods of measurement, as it were,

there will not have been a sufficient increase of stability and viscosity of the surface by the mere addition of the oil to cause the increase in viscosity which is necessary to the formation of a stable and persistent film. Finally, (Figure 4), taking the same case, this oil-covered surface, I will dust fine ore on it, and it will be seen that the chip again moves with the raft; that the surface has been stabilized and made highly viscous, viscous to the point of acting almost as a solid surface by the introduction of the finely divided solid matter into the film.

I will now perform the experiment. (A pan of water, the raft and a chip.) You will see that I can move this raft and there is no corresponding motion of the chip. (Adding dust.)

Q. 32. Mr. Williams: What material have you dusted in there?

A. I think that is some Butte & Superior ore.

By the Court:

Q. 33. Where is that chip?

A. The chip is over here. There must have been some grease on it from carrying it in my pocket, which causes the film to pull away from it. Now, you will notice that I can move the entire surface.

Mr. Scott:

2960 Q. 34. How would it do to add a new chip?

A. I hardly think it would make any difference.

By Mr. Williams:

Q. 35. Cut two or three chips off so as to get down to a clean surface.

(Witness cutting several chips off pencil.)

By the Court:

Q. 36. Does your magnet act on the ore as well as on the needle?

A. Not on this ore; at least that is the presumption. I think that I can show here that it does not. (Sticking magnet in a bunch of ore.) I think it can be seen very obviously that the whole surface there moves. (Ho'ding magnet near raft).

By the Court:

Q. 37. If you took your pencil would it move that scum?

A. I will try that. Yes, it does.

Q. 38. What does this illustrate now?

A. The increase in the viscosity of this interface between the gas and the liquid by introducing into that interface the finely divided solid particles.

Q. 39. Then it does not matter how you move the raft?

A. Not at all, not at all. Now, I will take another small pan, and I will put in water and the raft and a chip and I will add some wood creosote oil. There is no doubt of the contamination of the surface there.

By the Court:

Q. 40. What is this?

A. Here I am going to show that the increased viscosity of that interface is due to the introduction of solid matter, rather
2961 than to the introduction of the oil.

Now, you will see that the raft can be moved without the sphere of influence of the movement of the raft extending to the chip, although it can be seen by observing the film between the two arms of the raft, as it were, that that surface itself is acting like a solid; that is, the increase of the viscosity of the surface by the oil is sufficient to cause it to act almost as a solid through small distances, but that it is not sufficient to make it act as a solid over a considerable distance, and does not indicate the high viscosity that will be indicated when I put the ore on. (Sifting on ore dust.)

The surface has become so tough now that I have to get very close with the magnet to influence the needle.

By the Court:

Q. 41. Your mineral breaks up.

Mr. Scott: It needs more mineral, I guess.

(Witness added more dust.) I think the motion is shown here ahead of the raft, practically under my finger.

Mr. Scott: I offer the diagram just made by the witness and marked "No. 4, A. F. T."

Diagram admitted in evidence and marked Defendant's Exhibit 127.

Q. 42. Now, Professor Taggart, will you explain the relation of the experiment you have just performed to the permanency of the film, in flotation operation?

2962 A. I stated yesterday that the functions of oil in the flotation process were two: First, to assist in the formation of a stable froth; second, to assist in the selection of the sulphide mineral from the gangue. I said that the ways in which the oil assisted in the formation of a stable froth were: first, to decrease the surface tension of the water in the pulp, and I showed the decrease in the surface tension of water by means of oil, with the experiment No. 1. Then I stated that at the interface between oil and water there was formed a film whose viscosity was markedly greater than that of either the water or the oil or of the mixture of the two; and I showed that this morning by means of the experiment No. 2, the colored water bubble experiment. I said there that the oil assisted in the formation of a stable film by concentrating in the film and, being present in the film as a contaminant, having the power to move in the film and thus change the oil concentration in the film at any point in a direction which would tend to increase the resistance of the film to external forces. That I have not been able to illustrate by experiments. It is a matter, rather, of reasoning. Then, the other func-

tion of the oil, the selective action for sulphide as compared to gangue, is illustrated in experiment No. 3, in which it was shown that the oil tended to displace water at the surface of the sulphide particle, and that water tended to displace oil at the surface of the gangue particle. It is true, however, that in addition to the stabilizing influence of the oil alone, it is necessary for the formation of a persistent froth that there be present in the bubble film a load of solid matter, and the effect of that load of solid matter in stabilizing and making persistent the bubble film is shown in experiment No. 4 just performed.

2963

Q. 43. If we were to shake a bottle containing water and a little oil and then afterwards to shake a bottle similarly containing water and oil, but in addition powdered ore, is it your opinion that the result of the two operations would confirm the conclusion drawn from your experiment with the little raft this morning?

A. Yes, sir.

Q. 44. In the first instance, what would happen?

A. In the first instance, you would get some bubbles that would persist for perhaps a fraction of a second or a second, but obviously longer than they would persist if pure water alone had been placed in the bottle. In the second instance, you would get some bubbles that would persist considerably longer than the bubbles with oil and water alone. Just how much longer I would not dare say because that is a question of the quantity of sulphide present and the degree of agitation.

Q. 45. The second operation, with the oil, water and ore, is illustrated, is it not, by the two tubes containing the molybdenite froth which stand before the court?

A. That is what you should get with considerable agitation. I did not see those experiments performed so that I do not know.

2964

Q. 46. Can you state generally the condition necessary for the commercial success of a flotation process, as to the material treated, and so forth?

A. There are two conditions. First, that the solid material which passes into the froth shall be preponderantly sulphide, assuming that you are attempting to concentrate a sulphide from a worthless rock; and, second, that a very large percentage of the total sulphide present in the feed to the apparatus shall pass into the froth.

Q. 47. What is the effect of the emulsification of the oil and the agitation, as practiced in the flotation process?

A. As the process is ordinarily practiced the pulp containing the proper reagent, is placed into a device for agitating it violently. The idea of such agitation is to break up the oil that has been introduced into an extremely large number of extremely small particles or globules and at the same time to cause a certain number of the sulphide particles present in the feed to meet or come in contact with those oil globules and become coated with oil. Of course, at the same time that the sulphide particles are coming into contact with the oil globules, particles of gangue are also coming into contact with them, but, due to the tendency of the oil to replace water at the

surface of sulphide, the sulphide particles will become coated
2965 with the oil; and, due to the reverse tendency of the water to displace oil at the surface of gangue particles, the gangue particles will become coated with water. Then after the agitation in this primary agitator, in the so-called "emulsifying cells," the pulp is passed to another agitator which is so arranged that there is a circuit through into a box, a settling or separating box, in which there is no agitation and from which the pulp can pass back again either into the cell which it just left or through suitable passages into another cell. In these so-called "beater cells" of the process the pulp is filled with an enormous quantity of small air bubbles. Then, during the process of agitation, these bubbles, in a purely mechanical manner and under the ordinary laws of probability, will come into contact with either small globules or oil-coated sulphide particles, or both, or neither. Those bubbles which come into contact with an oil globule or an oil coated sulphide particle will immediately become coated at the air-liquid contact surface with a thin layer of oil. We have then the condition for concentration, for the separating of the sulphide particles from the gangue particles. That is, we have an air bubble surrounded by an oil film, and outside of that oil film the watery mass of the pulp. We have then, at the surface of the air bubble, a low surface tension due to the contaminant which is adsorbed or concentrated at the interface between the gas in the bubble and the surrounding liquid. There is
2966 present the viscous film which is characteristic of the interface between oil and water. We have also a place at which the sorting of the sulphide from the gangue can be done, and as sulphide particles and gangue particles are present in this interface for sorting, the sulphide particles, owing to the tendency of oil to replace water at the surface of the sulphides, will pass into the oil layer at the surface of the bubble; while the gangue particles, due to the tendency of water to displace oil at the surface of gangue particles, will be rejected at that interface and passed back into the mass of the water. Now, in a mass where there are present such stupendous numbers of bubbles and oil globules and oiled sulphide particles and unoiled sulphide particles it is obvious that there will be a stupendous number of chances offered for the sulphide particles to stick to and stay at the surface of the bubbles. When the bubbles arrive at the surface of the liquid, as they will when the pulp passes out into the separating chamber and there is a quiet place offered for the difference in specific gravity to allow the solid coated bubbles to so rise, there is a sufficient coat of sulphide particles to stabilize the bubbles and cause them to be persistent for a sufficient length of time to allow them to be scraped off or taken off by some means from the surface of the box and thus be separated completely from the gangue, which sinks in the box and is carried out at another point.

The froth that rises will, of course, be predominately sulphide
2967 and the solid that sinks and passes out in the so-called tailings discharge of the machine will be predominately gangue.

Q. 48. What is your opinion, Mr. Taggart, as to the effect of acid in the agitation-froth flotation process?

A. I think the acid has perhaps two functions. In the first place, acid tends to adsorb at the surface of gangue particles, that is to concentrate at the surface of gangue particles, in a manner exactly similar to that in which oil tends to adsorb or concentrate at the surface of water. Now, the result of this tendency of acid or acidulated water to adsorb at the surface of gangue particles is to insure that the gangue particles will be wet with—that is will pass into and will remain in—the water part of the pulp. The acid also aids in flocculating or agglomerating into rather large masses the very fine particles of gangue and thus aids in keeping these gangue particles out of the concentrate froth.

Q. 49. Have you formed any conclusion as to the effect of heat in the flotation process?

A. Heat, I think again has two functions. In the first place, it decreases the viscosity of the oils and hence aids in the distribution of the oil at the surface of the air bubbles. Even more prominently, however, it acts as a means of flocculating the finely divided gangue; and this flocculation is almost essential.

2968 Q. 50. What is the word you use?

A. Flocculating, that is the drawing together into masses of a lot of small particles. This flocculation is almost essential to the production of a clean froth; that is, one that is not carrying a considerable proportion of gangue.

Mr. Williams:

Q. 51. Clean concentrate, did you say?

A. Clean concentrate, yes.

Mr. Scott:

Q. 52. You have stated that this flocculation of the finely divided gangue caused a reduction of the percentage of gangue in the concentrate, but have you any explanation for that statement?

A. In the agitation in the so-called emulsifier cells and in the subsequent agitation in the beater cells of the flotation machine it is unquestionably true that an even larger amount or proportion of gangue particles is presented to the bubble surface than of sulphide particles, provided that the amount of gangue present in the feed is greater than that of the sulphide. The force tending to reject the gangue is a function of the surface of the particles, of the area of the surface. The greater the area, the greater this force. The film at the bubble surface or surrounding the air in the pulp is viscous, as we have shown, and in the case of these various small particles of gangue the viscosity of that film may be sufficient to hold the gangue particles in there against the force—the surface force, tending to throw them out. Now when the fine particles are agglomer-

2969 ated together or flocculated, they present a very considerably increased surface, and there is consequently an increase in this surface force, and the increase in the surface force is greater than the increase in the periphery of the agglomerate with respect to the original particles. The force of the viscosity at the inter-

facial film is a function of the circumference, as it were, of this flock. The periphery of course, as you increase the flock, increases as the radius, or as the diameter, in other words as the first power of that particular dimension of the body, while the area of the surface increases as the square of the radius. Consequently as you increase the size, you increase the area as the square of the radius and increase the surface force as the square of the radius, while you increase the circumference only as the first power of the radius and, hence, increase the viscosity only by the first power of that particular function; so that the increase in the surface force then is greater than the increase in the viscosity, with the increase in size of the particles; and consequently the surface force will tend to throw the larger flocks out while it is not sufficient to throw the smaller particles out against the viscosity of the film at the bubble surface.

I might say here that the increase in surface force is even greater than the increase of the square of the radius, due to the irregular shape of the surface of the flock. If the small particles which are flocked together are spherical, then the reasoning as to the
2970 first power and the second power of the radius would hold directly; but where the particle has a very much greater surface due to its corrugations than the sphere, then the increase in the surface power is even greater than would be true in the case of the sphere.

Q. 53. Is there anything in the theoretical basis of the agitation-froth flotation process that indicates a critical point in the quantity of oil relative to the ore?

A. Absolutely none that I can see.

Q. 54. What are the conditions that determine the amount of oil that must be used?

A. I think that the amount of oil that must be used depends upon three things: The amount of sulphide matter that is present in the feed, the amount of water that is present in the feed, that is, the degree of dilution, and the degree of aeration in the feed.

Q. 55. Will you state the relation between the amount of aeration or agitation and the amount of oil necessary?

A. If we consider in a cell or in a particular operation all things constant, except the degree of aeration, then any particular bubble in the machine will have a path whose average length is the same. There will, of course, be some bubbles that will go through the machine very quickly; there will be some bubbles that take a long time, that pass around and around in the beater cells before going out into the Spitzkasten; but taking the average of all the bubbles in the machine, then most of the bubbles will not depart very greatly from this average. The number of bubbles and the size of the
2971 bubbles with a given degree of agitation will also be approximately a constant. The number of globules of oil and the size of the globules of oil and the number of particles of sulphide—coated and uncoated with oil—will all be approximately constant figures, other conditions being the same, with a given degree of agitation. This means, then, that each oil bubble will carry approximately the same amount of oil, will have met approximately

the same number of globules of oil and the same number of oiled particles; consequently there will be a certain quantity of oil required to coat a given quantity of bubbles. If, now, by increasing the agitation, you beat in twice as many particles of air, the other things remaining constant (the number of particles of various things)—the number of bubbles will increase; we may assume for the sake of argument that they double, which they may not, of course, and if you have had present in the first instance just enough oil to coat the number of air bubbles that were present with the first degree of agitation, you will obviously not have enough oil present to coat the greater number of bubbles that will be formed with an increased amount of agitation; therefore, as you increase the degree of agitation it will be necessary to increase the amount of oil that is to be used, if it is expected that the bubbles are going to arrive at the surface coated with a sufficient quantity of oil to perform their function in the process.

Q. 56. Now will you state similarly what the relation is between the amount of sulphide present in the ore and the amount of oil necessary?

2972 A. The reasoning, of course, is entirely similar. In order to coat a given number of sulphide particles with oil—and you must assume that the great majority of the sulphide particles that are saved must be coated with oil—it is necessary to have a film of some certain minimum thickness on each particle. Now, as you increase the number of particles, it means, of course, that you must increase the quantity of the oil fed into the machine in order that each sulphide particle may have its coating of the minimum thickness of oil.

Q. 57. How does the amount of water present in the pulp affect the quantity of oil necessary?

A. Other things being constant, if you double the amount of water in a pulp there will be present in each cubic foot of pulp one-half the number of sulphide particles that there were present before. It is necessary, however, in order to insure that all the sulphide particles or a very great majority of the sulphide particles in the feed shall meet a globule of oil or an oil-coated air bubble, that there shall be present in each cubic foot of the pulp a certain minimum number of oil-coated air bubbles. In order to coat these air bubbles, a certain quantity of oil must be used; but where the pulp is dilute, you have to supply this number of oil-coated air bubbles for a very much smaller number of sulphide particles than when the pulp is thicker. Consequently the amount of oil necessary will depend upon the degree of dilution; as the dilution increases, the amount of oil necessary will increase.

2973 Q. 58. Suppose a soluble frothing agent were used, would the dilution of the pulp have a similar effect?

A. Yes, sir.

Q. 59. I think that it is a fair statement of what you have explained that in your opinion the amount of oil necessary is dependent on the amount of sulphide in the feed and the dilution of the pulp, rather than on the amount of solid matter?

A. Yes.

Q. 60. Is it your opinion that the attachment of air directly to the sulphide particles has anything to do with the agitation froth flotation process?

A. No, it has not.

Q. 61. Have you any experimental data in support of that conclusion?

A. I have examined a large number of bubble films under the microscope, the particular method followed being to take some newly formed froth on a ring, in such a fashion that I could quickly examine, first one side and then the other side, thus insuring that I was seeing what had been the outside of the bubble and also the inside of the bubble. In such examination I have found that in freshly formed films a very large majority—and by that I mean in the proportion of ten or twenty or thirty or forty thousand to one—of the particles present in the film, are entirely within the bubble film; that with just a very few exceptions the solid particles are at no point in contact with the air. Now, there need be a little care exercised in this particular examination, because in a film
2974 that has stood for a few minutes, if the film is sufficiently loaded with solids to remain for a considerable length of time, the larger particles of solid matter present in the film will commence to poke through; they do not break up the film, but the particles poke through, and the film will draw down over them, leaving the solid particles very apparently sticking through, and such is not the condition as the fresh froth reaches the surface. If, however, you attempt to photograph, it is necessary, of course, to get a froth or a film that will stand for a considerable length of time—that is, a thick film, and I have not yet been able to photograph within the thirty seconds or a minute that are necessary, if I would insure that all the particles remain within the film—so that photographs all show some particles sticking through. However, it is possible, I think, that you can examine it here through the microscope—examine some freshly formed films and see that the particles are almost all within the bubble film. I will perform that experiment if you like.

Q. 62. Well, I think you might as well do that.

A. I think we have the square jar machine here.

By the Court:

Q. 63. You say the particles are in the film of oil surrounding the air?

A. There will be a bubble film with air inside, and a surface with air outside. Now, the solid particles are completely within that film, and the film will raise up over the solid particles and, underneath, the film will come down under the solid particle, so that the
2975 particle is completely enclosed within the film, and there can be no question of the attachment of air for the particle itself. It is true that there is some selective attachment of air for sulphide particles as opposed to gangue particles, and in some of the earlier

investigations of the subject it was thought that this actual attachment of the air for sulphide in preference to gangue was an explanation of the flotation process; but by examining these froths, it can be seen that air is not in contact with the solid particles at all as they come to the surface in the bubble film.

Q. 64. Could you illustrate that with a little diagram, the position of the mineral particles in relation to the bubbles?

A. I can. If this particle is here as the small particle in the film, then one surface of the film will come along in this fashion and rise up over and surround the solid particle, while the other portion will come over in this fashion and then come down around the solid particle in that way (drawing). Now, after that film has stood for a short length of time, the condition presented will be something like this (drawing). The solid particle will stick out in such fashion as that. This film has already been raised to the surface; flotation has been done; all that remains is to scrape it off within a period of twenty or thirty seconds or a minute or so subsequent to this. This is the kind of its activity in the ordinary separation in the machine.

Q. 65. In referring to the face that was active in the
2976 process, did you have reference to the upper or the lower drawing in the sketch?

A. To the upper drawing, the one that is numbered No. 1; and the second represents the condition after the bubble film has been some time at the surface.

Q. 66. Now, will you mark that diagram 5?

A. Diagram No. 5.

Mr. Scott: I offer this diagram in evidence, No. 5.

Admitted without objection marked Defendant's Exhibit No. 128.

Q. 67. Does it require a fresh froth in order to see this?

A. Yes. I thought he had the square jar machine down here, but it seems he has not.

The Court:

Q. 68. I do not understand what film that is; is that the oil coating of the air bubble?

A. Yes, that is the film around the bubble. The situation of the surface, if you consider this just a single bubble, will be something like this. Now, if I enlarge that particular film——

The Court: I think I understand now, Professor; I did not know for sure what you meant.

By Mr. Williams:

Q. 69. Which is the outside of the bubble in your diagram; is it the top?

A. It does not make the least bit of difference.

By Mr. Scott:

Q. 70. Referring to the circulating load in the flotation process, that is, the return of the middlings to the head of the ma-
2977 chine, what is your opinion as to the condition of the oil that comes back with the middlings, that is, whether it is all adhering to and appropriated by mineral particles or not.

A. It is not, I think, all adhering to and appropriated by mineral particles.

Q. 71. What is your reason for so stating?

A. We are speaking now of the agitation froth process?

Q. 72. Yes.

A. In the later cells of the agitation froth machine, the froths are much more fragile, much less persistent than the froths in the earlier cells. Now, the persistence of the froth depends, of course, upon the load of solid matter contained in it. The less persistent froths, therefore, will have a smaller load of solids contained within them than the more persistent. It is the less persistent froths that are circulated. The bubble film itself consists of a complete layer on each surface, in which is concentrated oil, and the concentration lessens as you pass toward the center of the film. In other words, the whole area of the bubble film has oil upon it. If the solid particles do not occupy the whole area of the bubble film, then it must be true that between the solid particles there are areas of bubble film unoccupied by solids. But as the oil covers the whole area of the bubble film, then these areas which are unoccupied by solids are yet occupied by oil, and that oil is, of course, not appropriated by the solid matter, and is therefore unappropriated oil which is available for use in the circulating load as it comes back into the machine, for coating sulphide particles in the new feed.

2978 Q. 73. How do you explain the fact which has been referred to that in flotation plants where heavy collecting oil is used in large bulk in connection with a lighter, so-called frothing oil, and the heavy collecting oil is discontinued, the froth has been observed to cease entirely?

A. The heavy collecting oil, so-called, is used in much greater quantities than the light, frothing oil; in other words, the amount of the light frothing oil added per ton of sulphide mineral present in the feed is extremely small; so small, in fact, that it would not coat enough air bubbles and collect enough solid matter to satisfy the requirements for the formation of a stable froth.

Q. 74. Instances have been referred to by witnesses in which the use of a large amount of oil made a more abundant froth than smaller quantities. Have you any explanation of that?

A. It is unquestionably the case in the agitation or in the beater cells, that a considerable number of air bubbles, under ordinary circumstances—particularly where small quantities of oil are used—pass through the process of agitation and on through the Spitzkasten without becoming coated with oil, and with solid particles. As the amount of the oil is increased, the number of chances and the probability of all the air bubbles becoming coated with oil, of course,

increases, and the number of bubbles which do become coated with oil will increase according to these chances and probabilities. It is also true that in the ordinary agitation-froth process the
2979 bubbles—particularly in the first cells—are coated more heavily with solid particles than is absolutely essential to their persistence for the length of time required for their removal from the machine; so that there is present then sufficient sulphide to distribute over these additional oil bubbles that are formed when more oil is put in, and stabilize them, and thus increase the number of stable bubbles in the froth. In other words, increase its volume. I think that is the explanation of the increase in the volume of the froth with increasing oil.

Q. 75. It has been stated that the use of the oil referred to as Jones oil produces a very voluminous froth when used for the flotation of vanner tailings, but that this phenomenon is not observed when the same oil is used upon the low grade vanner concentrate. Can you explain that fact.

A. I have just stated that there was present in the froth of the first cell of the ordinary agitation-froth machine an excess of sulphide material above that required to stabilize the froth for the required length of time. The lessening of the amount of solid material in the froth means a lessening in viscosity of the bubble film while it may yet remain sufficiently viscous to be stable for the necessary length of time. However, as one of these lightly loaded bubbles comes to the surface the air contained within it of course tends to expand with the lessening of the pressure due to the decrease of hydrostatic head and the film will therefore expand as far as the viscosity will allow it. Vanner tailings are low grade, that
2980 is they contain a small per cent only of sulphide mineral. Consequently there will be a relatively small percentage of the stabilizing sulphide material present in the froth and the tendency of the bubble to expand as it reaches the surface is not overcome by the viscosity of the froth. The bubble will therefore expand and make the very voluminous froth that is complained of in this particular connection. On the other hand, in the vanner concentrate machine the feed is richer, contains a larger amount of sulphide. There is, therefore, a considerably larger load of sulphide present in each bubble. The degree of agitation being about the same, the viscosity of the film surrounding the bubble is so great, due to the greater amount of sulphide present in the film, as not to allow the bubble to expand under the decrease in pressure. Consequently you get the characteristic small-bubble heavy froth with these vanner concentrates and get away from the over frothing that is complained of with the Jones oil and vanner tailings.

Q. 76. Will you state whether or not it is essential, in your opinion, that the sulphide particles be coated with oil before leaving the emulsifier or before entering the flotation machine, in order that they may be emulsified in the bubble film?

A. It is not essential. In the beater cell we have present oil globules or air bubbles in numbers that are almost beyond comprehension, and while it is possible that a sulphide particle not yet oiled may not

become oiled in the beater cell, yet it is extremely unlikely
2981 that any sulphide particle can miss meeting one of the oil bubbles or the oil globules in the beater cell when there are such enormous numbers present. It is a pure question of chance.

Whereupon an adjournment was taken until 2:00 P. M. Wednesday, April 25th, 1917.

2:00 o'clock p. m., April 25, 1917.

Q. 77. If you are ready now, professor, we will go ahead with the experiment of examining the bubbles under the microscope taken from the flotation froth.

A. All right, sir.

Q. 78. Describe first how the froth is to be made, and what of.

A. This experiment is intended to confirm the drawing which I made on the board, diagram 5, showing that the solid particles within the froth are, most of them,—almost all of them, included within the bubble film; by that I mean, not inside the bubble itself and in contact with the air inside, or outside the bubble and in contact with the air outside, but in contradistinction to that, entirely included within the film of the bubble itself, and not in contact with the air either on the inside of the bubble or on the outside of the bubble.

I hope to show that, by taking the froth on a ring and placing the ring under the microscope and examining first one side of the film, which will be stretched on the ring and which will be the outside of the bubble as it appeared in the froth; then turning
2982 the ring over and examining the other side, which will represent the surface of the bubble which was toward the inside. The froth which is to be used will be made by mixing a charge as follows, in the Janney experimental machine: 400 grams of Butte & Superior ore; 2,000 cc. of water at a temperature of 30° C.; 9/10 of a cubic centimeter of sulphuric acid of a specific gravity of 1.84; 1 cc. of copper sulphate solution; 5.2 cc. of oil mixture—of the particular mixture which is used in the Butte & Superior mill. That will be agitated, and in order that I may get a froth which is not so heavy as to be classed almost as a mud, I will skim off the first froth that comes up and get down to some of the later froths, where the particles are more widely separated in the film, and therefore more easily to be observed.

Q. 79. Professor, you might state to the court in a very few words how that Janney machine works. It has nothing to do with this experiment, but it is a convenient time to explain it.

A. The machine consists of a cylindrical portion, in which is a central shaft carrying two beaters, one about this point in the lower part and one at about this point in the upper part of the machine. At one side is the separating box in which the solution or pulp is much quieter, naturally, than it would be in the agitator. The separating box is connected with the cylinder at the bottom and at the upper portion. Surrounding this cylinder is this annular box, into

which the froth is thrown by means of the beaters. The froth
2983 is then discharged onto the surface of the water in the separating box. The froth, of course, stays at the surface, so that the liquid containing the gangue, as the stuff is thrown out, settles and is drawn back in again through the opening at the bottom, thus having a circulation which, in some ways, is similar to the operation of the Janney machines which are used.

The Court: The court is assuming he is doing the thing he said he would, and these other gentlemen are watching. I don't know as it will add any to see him put in the material.

Mr. Williams: I think it would be well to keep an open space between the eye of the court and the machine.

The Court: When it is operating.

The Witness: (Gathering bubbles from the froth produced by the Janney machine.) Now, this has to be looked at rather rapidly. I think that will thin down. You see there is a bubble both this side and this side. Now, I have broken that so that I have both the inside and the outside of that bubble face as it stood. Now, if we can look at it under the microscope I think your honor will see that the film comes up and surrounds the large particles.

The Court:

Q. 80. How many diameters is that?

A. Somewhere between 25 and 40. I haven't it exactly.

The Court:

Q. 81. These protuberances that are bright, by reason of the reflection, those are what you term the mineral inside the film?

2984 A. Yes, the film comes up over that. You will notice the film is raised up, a little mount above that. And I will show you the other side (turning the material over).

Mr. Williams:

Q. 82. Which side is that that is exposed?

A. I don't know. There is no difference between the sides.

Mr. Scott:

Q. 83. Will those particles project through the film if we leave it there five minutes or so?

A. They will if the film does not break before. If the film is sufficiently viscous to last. What I got there was a bubble somewhat like that with the wire coming right along the side of this and then I took my pencil and pricked one side of that so that I had the inside and the outside of the bubble.

Mr. Williams:

Q. 84. What you really have is a film of water containing mineral?

A. A film of water and oil, a film containing oil concentrated at the air surfaces.

Q. 85. Both surfaces?

A. Both surfaces, and in that film the solid material.

Q. 86. Where is the water?

A. The water is at the center of the film and the water is most highly concentrated at the center of the film, the oil most highly concentrated at the surface.

Q. 87. Now, I am looking at this through the microscope, and what I see is a few particles here and there that are metallic, and a great deal of material that is apparently gangue. Is that right?

2985 A. It might be. I would like to look and see whether I would check your observation. If you will qualify by saying apparently gangue, I will agree with you. I would not attempt to make the distinction between the rather light particles that are present and the gangue without more practice with the microscope on that particular ore.

Q. 88. Now, I can not see anything covering the metallic particles, can you?

A. I think if you will look now, Mr. Williams, that you will find that the surface of the film comes up over the larger particles in an entirely smooth and regular way, different from the irregular surface that would be presented if you saw the mineral itself.

Q. 89. I see nothing except bright metallic surfaces protruding upward.

A. Through the film?

Q. 90. I am unable to recognize the film. Can you tell me how to recognize it?

A. By its rather moist and somewhat liquid appearance, as opposed to the decidedly not-moist and decidedly not-liquid appearance of the solid matter.

Q. 91. Isn't it a fact that the metal particles are cleaned by this operation of terrific agitation to which they are subjected?

A. What do you mean by "cleaned"?

Q. 92. I mean polished, or the gangue removed from them?

A. No, sir.

Q. 93. You would expect to find dusty surfaces in that pulp?

2986 A. Not dusty, no.

Q. 94. Wouldn't you expect to find clean surfaces of metal in that pulp?

A. Of the metallic particles, yes, but not particles that had been cleaned due to agitation, but rather due to the preliminary grinding that they had received.

Q. 95. And being cleaned, wouldn't they be bright?

A. They would, but they would not be liquid looking. They would not have the smooth and regularly curved surfaces, but would have angular surfaces. I think perhaps in order to show you the difference, I should take some of the original ore and put it in there and let you see the difference between the angular appearance of the dry ore and the smooth appearance of the liquid film.

Q. 96. In any event those metallic particles are to some extent coated with oil, are they not, as they exist in that bubble?

A. Unquestionably, sir.

Q. 97. And they would still be coated with oil if they were separate and apart from the bubble?

A. Unquestionably.

Q. 98. And that would make them glisten, wouldn't it?

A. Yes. They would not, however, I wish to state here, be in contact with the air if they were entirely coated with oil.

Mr. Williams: That is all the cross-examination as to this particular experiment.

2987 Direct examination (resumed).

By Mr. Scott:

Q. 99. Professor Taggart, will you arrange in the microscope some of the dry ore that was used in this experiment, and if it is practical also expose some of the mineral particles out of the froth, covered by oil but separate from the bubble film, if that would be practical.

A. Yes.

Q. 100. Well, since you are not quite ready we will ask another question. Can you explain how it is possible that the amount of oil per ton of solids in a flotation system having a circulating load can be greater than the amount of oil initially fed into the machine per initial ton of feed?

A. I think I can explain that statement. It is not exactly accurate. There is present in the circulating load, naturally, no more oil than was originally fed in with the pulp; there is no device of course in the machine for the manufacture of oil. There is, however, this condition present, that the oil passes through the machine—the oil in the circulating load—at a rate considerably greater than the rate at which the original oil is fed in; or at least that is a possibility; it may be the other way. I think I can illustrate by a diagram just the distinction that I am trying to make between the amount of oil and the rate. If you consider this drawing to be the cylinder of a pump, this to be the piston and this the piston rod; S, the
2988 suction end of the pump and D the discharge end of the pump, and that this is a pipe running around from the discharge end of the suction end; and if we assume that there is an opening in the top of that pipe, so as you could fill this whole system with oil, the pipe at this end of the cylinder (D).

Q. 101. You might indicate by letters as you go along.

A. The point for the introduction of the oil I will mark A; and if we introduce at A enough oil to completely fill the system, the pipe, the discharge end of the cylinder and as much of the suction end of the cylinder as is not taken up by the piston rod itself, and if we assume further that the total quantity of oil in there is, we will say, 25 gallons, now we start pumping, and the oil of course, will circulate—in this fashion, around through the system. Now, if at any time we were to open this pipe and for a given length of time collect the oil that discharged—we will say for 30 seconds, and in that time we collected a gallon of oil—which is all within the realms

of possibility—then we would have oil passing through that system at the rate of one gallon in thirty seconds, or 2,880 gallons per 24 hours, while you have only present in the complete system, 25 gallons of oil. It is a question of rate.

The same thing applies in the return system in the flotation process; there is present all the time an oil circulating, similarly to the oil circulating in this system. It is measured by cutting the stream of pulp for a given amount of time, by analyzing the
2989 pulp that is cut for oil, and by drying some of the pulp and weighing the solids in it. We have then the rate at which the oil is flowing through that system, and the amount of the solid that is flowing with the oil in the circulating system, so that there is cut from the middling charge in a second a given number of pounds of solids, accompanied by a given number of pounds of oil, which is the oil in the circulating system. If this is greater than the amount which is meant to be fed to the machine per ton of solid matter entering the machine, then it should be credited to the new oil which is necessary in order to bring the total amount of the oil entering the machine up to the desired proportion to the total amount of solids entering the machine. If the amount of oil is smaller than that fed in with the new feed, then new oil has got to be added in excess of that required by the new one. In order to furnish to the old pulp circulating through the machine enough oil to bring the oil in that pulp up to the amount that is put in with the new feed, and the total oil entering up to the proper proportion to the total amount of solids passing through the machine.

Mr. Scott: I offer in evidence this diagram just referred to by the witness and being marked "Diagram 6 A. F. T."

Diagram admitted in evidence and marked Defendant's Exhibit No. 129.

The Witness: (Producing a sample grain of ore and placing
2990 same under the microscope.) I think that will show, Mr. Scott, the desired angular character of the particle and I think Mr. Williams may be able to see a difference between the rather angular particle there and the rounded surface of the film as it comes up under the original particle.

Q. 102. What have you placed under the microscope?

A. I have placed that portion of the ore which remains on a screen of approximately 80 meshes I think, yes, 80 mesh.

Q. 103. What is the nature of this ore you put on here now?

A. It consists of a large particle of solid material from this Butte & Superior ore which was used in the previous tests.

Q. 104. This is some of the same ore that was in the froth?

A. No, but some of the same ore that was fed to the machine. I will take some of the ore in the froth later. You can notice the angular character of it. This is some of the material out of the froth. Note how much more angular that is.

Mr. Williams.

Q. 105. That is some of the concentrate you have just put into the microscope?

A. Yes, sir, that has been vanned out of the froth.

Q. 106. Why does it contain so much more of the gangue particles, large gangue particles than the one which you first showed?

A. I am sure I cannot say, sir. It was taken from a differ-
2991 ent part of the froth and furthermore the oil and the very fine particles which conceal what is in the froth have been removed here, making the presence of any large gangue particle much more easily discerned.

Q. 107. It is your understanding then that the free oil has been removed from this concentrate?

A. No, some oil unquestionably has. It would be very easy to prove that there was still oil present there.

Q. 108. But some oil has been removed from it?

A. Oh, unquestionably, yes.

Mr. Scott:

Q. 109. You referred this morning to the relation existing between the oil and the amount of sulphide mineral in the ore, between the amount of oil and the number of air bubbles or degrees of aeration, and the third relation between the amount of oil and the dilution or the amount of water in the pulp. I wish you would state whether either of these three relations can be expected to so preponderate under given conditions as to make the rule plain in the case of any given ore or in comparing any two given ores or two given systems of treatment?

A. Under test conditions only would it be possible to trace absolutely the relation between the amount of oil necessary and any one of the three factors, aeration, dilution and percentage of sulphide. The method, of course, would be to keep all conditions standard except the one particular condition under investigation and then vary that amount. Under mill conditions the relation may be considerably harder to distinguish, because, except in most exceptional cases, the ore varies from day to day through, it may be considerable limits in percentage of mineral content or in the percentage
2992 of dilution. It is possible of course in the mill to keep the degree of aeration constant but these two conditions of percentage of sulphide present and dilution will vary quite widely without the control of the ordinary operator in the mill. There will unquestionably, however, arise cases in which the relation between the amount of water and the amount of oil required or the amount of sulphide matter and the amount of oil required can be distinguished in mill operations. Some of the figures that have been presented by the men from the different mills to date indicate that they are confirming this opinion, and while I have not the definite figures at present at hand to confirm from these mill sheets, I think that that can be—could be studied out. The amount of oil can be disposed of in the process, that is the range through which you can

carry the oil with a given ore and under given conditions is rather large, and in my discussion this morning I tried to make it clear that I was speaking of the required amounts of oil to get certain conditions. That is, if, with all our conditions constant, you had been working with a minimum quantity of oil to do the work and you increased the amount of sulphide in the feed, then in order to get satisfactory conditions it would be necessary to increase the amount of oil added; or in the case of the dilution, if, all other things being constant, you had been working with a minimum quantity of oil necessary to produce a certain result with a given dilution, and if you increased the dilution—that is the per-
2993 centage of water—then it would be necessary to increase the amount of oil added in order to get the result that you had been obtaining before. And the same thing of course, in the case of aeration. It is true, moreover, that the condition has been presented by some of the previous witnesses that when they increased the quantity of oil that they added to the froth they decreased their agitation and they said that they did this in order to get good results. I think the explanation of that is that, not having varied the sulphide content and having more oil present, it was not necessary to do such a large amount of agitation in order to insure that the requisite amount of air bubbles for the collection of the sulphide material in the froth would be coated with a sufficient film of oil to serve their function. Consequently they decreased the amount of their agitation. And they further found that if they did not decrease the amount of agitation that they got what we may call over-frothing, that the froth overflowed the spitzkasten and ran all over the mill. I think the explanation of this is the fact that it is possible to stabilize the bubbles with a considerably smaller amount of solid material than is ordinarily the practice in the machine; that when they add the greater quantity of oil and thus coat a larger number of air bubbles, there having been some air bubbles coming through without an oil coating when the minimum amount of oil was used, the greater number of oil coated air bubbles each took up a smaller load of solid material, the load of solid material was sufficient to stabilize
2994 and consequently there was this increased number of air bubbles each with a sufficient load of solid material to stabilize it rising to the top of the spitzkasten and overflowing the spitzkasten. Therefore, they reduce the amount of agitation, reducing the number of air bubbles that were rising to the surface, loaded each one more heavily with sulphide material and thus reduced the over-frothing.

Mr. Scott: You may cross-examine.

Cross-examination.

By Mr. Williams:

X Q. 110. You have mentioned particularly experience in the mill of the Nevada Consolidated Mining Company at McGill, Nevada. How long ago was that?

A. 1910.

X Q. 111. Did they use any flotation then?

A. No.

X Q. 112. In what manner was the ore concentrated, generally?

A. Tables and vanners.

X Q. 113. Water concentration?

A. Water concentration.

X Q. 114. Were there slime losses?

A. Yes, sir.

X Q. 115. Very considerable slime losses, were there not?

A. Quite considerable. I speak now with the viewpoint of an operator. I was not in a position of such authority there as to know the figures of recovery of the company.

2995 X Q. 116. But they were constantly impounding slime tailings, weren't they, that were of considerable value?

A. That I couldn't say. They were passing the slime overflow through settling ponds, which would of course have the result of getting some of the contained values.

X Q. 117. What kind of an ore did they have?

A. The ordinary so-called porphyry ore.

X Q. 118. A lean copper ore?

A. Yes, with considerable iron sulphide present.

X Q. 119. When did you last learn of their operations, from inspection?

A. In the fall of 1910.

X Q. 120. So that you do not know that since then they have adopted flotation and are now getting very fine results?

A. Not of my personal knowledge.

X Q. 121. And then the Montgomery Shoshone Mining Company. When were you there?

A. In 1908.

X Q. 122. What kind of an ore?

A. Gold ore.

X Q. 123. No flotation then I take it?

A. No.

X Q. 124. When was your attention first called to flotation concentration of ores?

A. When the articles concerning it first began to appear in the mining periodicals.

X Q. 125. About?

2996 A. I should presume that I became interested in that back along in 1912—probably 1911 or 1912.

X Q. 126. Did you write or participate in the writing of an article which appeared in "Metallurgical and Chemical Engineering," volume 15, November 1, 1916?

A. I can't remember the particular date of its appearance. I think I can identify the article.

X Q. 127. I show it to you?

A. Yes.

X Q. 128. I read from that article as follows: "The importance of flotation lies in the fact that it is primarily a 'slimes process,' by means of which the particles of valuable mineral too fine for efficient

gravity concentration are saved with a high percentage of recovery. Recovery in the mills treating low grade copper sulphide ore have been advanced ten to twenty per cent by the installation of the process and similar increased saving can be accomplished by the same means in mills treating sulphide ores of zinc and lead." That is a part of the article that you published and read before the American Institute of Mining Engineers in September, 1916?

A. It was presented before them. I did not read it.

X Q. 129. And you accept those statements as true today?

A. To the best of my knowledge.

X Q. 130. I read from that article as follows: "(1) That water has a smaller tendency to displace air on the surface of sulphide minerals than on the surface of gangue minerals: (2) that the ten-
2997 dency of oil to displace air is greater at the surface of sulphide minerals than at the surface of gangue minerals; (3) that oil tends to displace water on the surface of sulphide, and that water tends to displace oil at the surface of gangue minerals; (4) that water displaces air more readily on an oiled solid surface than on a clean surface of the same solid; (5) that these tendencies towards displacement are due to the interfacial tension or pressure existing between the various substances and that the resulting action of this interfacial force is a manifestation of the tendency towards reduction of the total potential energy of the system. Wherever an increase in the solid-fluid surface will decrease the potential energy, such a change will occur." You accept those as statements which you to-day will advance?

A. Yes.

X Q. 131. And following in this article is a description of an experiment to demonstrate the fact that water tends to displace air more readily from an oiled metallic surface than from a non-oiled metallic surface. Will you accept that as a fair statement of what you demonstrated in the article?

A. Yes.

X Q. 132. What is the difference between adsorption and absorption?

A. Absorption is the taking into the mass of a substance—some other substance, and as ordinarily used I think it is considered that the substance taken in by absorption passes through and diffuses through the mass of the absorbent. I may use a homely illus-
2998 tration, of a sponge placed in water; the sponge absorbs the water. Adsorption is the concentration at the surface between two phases—physical phases—of some substance which is a contaminant of one of the phases, under the rule that in a mixture of two substances, that the substance which will tend to reduce the surface tension of the system will tend to concentrate or adsorb at the contact of the system with some other phase.

The Court:

X Q. 133. How does that apply to this question?

A. The question of flotation, when you have in the mass in the

beater cells small globules of oil and small bubbles of air, when a particle of air and oil are brought closely enough together so that these forces which tend toward adsorption and which are rather small forces—can act, then the oil will spread itself over the entire surface of the air bubble within the pulp, because by so doing it can lower the surface tension of the pulp at the gas-liquid interface; the gas and the liquid being the two phases, and the oil the contaminant in the liquid, which tends to concentrate or adsorb at the interface between the two phases.

X Q. 134. In testifying in regard to what you have called the agitation froth process, you have confined your description to the agitation in one vessel and separation of the froth in another as I understand it; is that right?

A. Yes.

X Q. 135. You are aware, are you not, that the process is carried out with an agitator at the bottom of one vessel; air flowed in
2999 at the bottom of that vessel and the froth taken off at the top of the same vessel; that is known as sub-aeration; are you aware of that?

A. Yes, I have heard of it.

X Q. 136. And then there is another variety, is there not, wherein there is no agitator in this vessel, but the air is broken up by flowing in underneath through a porous medium, and flows up, and the froth is taken off at the top?

A. Yes.

X Q. 137. And referring to that, did you, in this article, state as follows:

"The principles involved in this method are the same as explained in the agitation-froth process. The only difference is in the method of introducing air. The result of this difference is that the bubbles in the pulp are much larger than in the agitation-froth method; they arrive at the surface less heavily loaded in proportion to their weight. The bubbles films are therefore less viscous and the froth less persistent."

A. Yes, sir.

X Q. 138. Now, in the description that you have given of the bubble action in connection with the oiled mineral, I have not exactly understood what was the condition of the submerged bubble carrying the mineral or the sulphide particles attached to it, before its emergence above the surface of the liquid. Could you describe the condition of that bubble submerged with the metal particles or sulphide particles attached to it?

3000 A. I think I can.

X Q. 139. Please do so.

A. Of course that is something that is not capable, in the cell, of actual observation; but reason should lead to some such situation as this: (drawing) This represents a bubble in the mass of the pulp, and at some subsequent instant that bubble has met with a small globule of oil.

By Mr. Scott:

X Q. 140. Won't you please letter those points as you pass along?

A. Yes, I will do that. The bubble A, in the mass of the pulp B, having met a globule of oil, will become surrounded by a film of oil which is concentrated at the surface between the two phases, gas and liquid. The reason for such concentration is that by means of it the mass marked "B" can reduce its surface energy. The degree of concentration will vary from a maximum at the actual air surface to nothing or practically nothing at a distance away from it, and there will be present then, because that variation takes place through a very short distance—an interface or film, similar to the film or interface presented here between the oil and the water. The situation being on a much exaggerated scale, we might take the atmosphere of the room for the air of the bubbles, and the oil adsorbed at the air surface here and the water here, and here the point of varying concentration—or the place of varying concentration of the oil and water, from full concentration of the oil to full concentration of the water, being a very small distance.

3001 X Q. 141. Will you say what you referred to in your answer; you did not describe it.

A. I refer to the red water and bubble experiment performed this morning. If we consider then, that this line (drawing) represents that interface, the line being marked C-D on my sketch, and at this side we have water and at this side oil, and if we consider, presented at that interface in some such fashion as that, a particle of sulphide mineral, and if we consider that that interface, the line C-D, is a fixed part of our system, and that the particle of solid matter is a moveable part of the system, then, due to the tendency of the oil to replace water at the surface of the sulphide particles, and due to the further fact that the line C-D here is fixed and can not move, then the sulphide particle itself must move, and the sulphide particle will move over into the oil. The reverse condition holds with the gangue particles. Here, assuming the line C-D or the plane represented by the line C-D, to be fixed, and the solid particle, the movable part of the system, then, due to the tendency of the water to replace the oil, in order to satisfy that tendency, the gangue particle must move into the water, and at that point you get the separation, so that you finally have then these particles of sulphide moving into the film—I will mark them "S"—moving in near to the air-liquid interface within the mass in the beater machine. I have marked this diagram No. 7.

Mr. Scott: I offer this diagram which Prof. Taggart has marked No. 7 in evidence.

3002 Diagram admitted in evidence without objection marked Defendant's Exhibit No. 130.

X Q. 142. Now, Prof. Taggart, is there such an adsorption as you have spoken of at the oil-water phase—is there not an oil-water phase there, too?

A. Yes.

X Q. 143. Is there an adsorption at that interface?

A. Adsorption of what?

X Q. 144. That is what I would like you to tell me.

A. I don't know of any particular adsorption there that is of any importance in the particular discussion. It is probable—it is true that if there is present in either the oil or the water any contaminant which, by adsorbing or concentrating at the interface between the oil and the water can reduce the tension at that interface, that there will be adsorption of that particular contaminant at that interface, but I do not know of any such contaminant present in the flotation process which would tend to adsorb and have any particular effect on the operation of the process.

X Q. 145. Now, that layer of oil which surrounds the hole in the water that the air makes——

A. The hole in the pulp, you mean, do you not?

X Q. 146. Yes, the hole in the pulp; that layer of oil is a definite layer, distinct from the water, is it?

A. I have indicated here a zone of transition from the highly concentrated oil to the highly concentrated water, and I have drawn the parallel here to the colored water-oil test; assuming this as a section on a very large scale of an air bubble of which the atmosphere of the room here forms the air. You see there concentrated
3003 at the air surface, due, I grant you here, to the force of gravity, a layer of oil, and there is a layer right at this surface between the oil and the water, through which the concentration varies regularly from a concentration of all or practically all oil, less and less and less oil to a concentration of practically all water. There is no actual discontinuity there, but the distance through which that variation in the concentration takes place is so small as to look like a sudden transition to the naked eye. Now, a similar transition takes place at the surface of the bubble in the pulp.

X Q. 147. Would you call that an adsorption layer?

A. Unquestionably that would be an adsorption layer between the two liquid phases.

X Q. 148. When the bubble is then immersed so that it is merely a hole in the pulp filled with air, would you say that it has a film about it?

A. I should think that would be a question of the definition of a film. Speaking accurately, I should not; I should say that it had about it a layer of oil which has this property that I have been repeating, of varying its concentration from the greatest concentration of oil at the air-liquid interface, gradually tailing off, decreasing until you get to a maximum concentration of the water at a distance from the bubble.

X Q. 149. In talking of the oil as you have in the last few answers, have you reference to an insoluble substance?

3004 A. I presume you mean by insoluble the word as it is applied ordinarily to what are called insoluble oils as differentiated from the so-called soluble oil?

X Q. 150. Well, take it that way and explain it.

A. I should say that the difference there is merely one of degree,

and not of kind. That same thing would occur whether I were describing soluble oils here or the so-called insoluble oils; the difference being that the layer through which you pass from maximum concentration of oils to maximum concentration of water would be somewhat thicker, and bearing in mind that that change takes place through such a small distance here that it is practically impossible to distinguish it with the naked eye, you would still have the working condition about as presented in the previous discussion.

X Q. 151. Well, let us take the case of a completely soluble modifying agent—frothing agent—dissolved in the water; what will happen then in the submerged air bubble?

A. Are you willing to further qualify your answer by stating that the oil or soluble modifying frothing agent will lower the surface tension of the pulp if it concentrates at the air-pulp contact?

X Q. 152. As I understand it, that is a characteristic of all frothing agents, that they lower the surface tension.

A. I just wished that to appear in the question.

X Q. 153. That is your understanding, is it not?

A. That is my understanding. If, then, that agent will lower the surface tension by adsorbing or concentrating at the gas-
3005 liquid interface, it will so concentrate and adsorb.

X Q. 154. Now, under such a condition, the dissolved frothing agent is normally distributed throughout the whole mass of water and pulp?

A. Yes.

X Q. 155. You agitate so as to introduce air, or you introduce air by any other means, and you get a bubble in the pulp?

A. Yes.

X Q. 156. Now, what kind and degree of concentration do you get around the wall or surface of that submerged bubble?

A. A sufficient concentration to lower the surface tension of the pulp at the gas-liquid interface.

X Q. 157. Now, when the metallic particle meets that kind of a bubble, what happens?

A. The same thing exactly as happened in the case represented on the blackboard, provided that there is enough of this so-called soluble frothing agent there to coat the ore particles in the froth with a sufficient film of oil to allow of the selection of the gangue from the sulphide.

X Q. 158. Now, in order to get away from oils, which you have rather interjected into your answers—suppose we take acetic acid as the soluble frothing agent, which reduces surface tension and produces, under the use of agitation and aeration, metalliferous froth—you know it does that?

3006 A. I have not done it experimentally, I will take your word for it.

X Q. 159. Isn't it a known fact among students of this subject that acetic acid will do that?

A. I have heard of it, but I have not seen it.

X Q. 160. Well, upon that assumption you can go ahead and tell

me what will happen; describe the condition of the concentration or the condition.

A. The acetic acid in this particular instance plays the part which has been ascribed to the oil in the preceding discussion, provided that the acetic acid will lower the surface tension of the pulp, if it concentrates or adsorbs at the gas-liquid interface. I have not looked the figures up on that, nor have I made any experiments on it, so that my answer is based entirely on general reasoning, as concerns the process.

X Q. 161. I unfortunately selected a soluble frothing agent with the action of which you were not familiar. What soluble frothing agents have you operated with and are you familiar with?

A. I am not particularly familiar with the action of any of the so-called soluble frothing agents as opposed to the so-called insoluble frothing agents, Mr. Williams. My work to date has been most largely attempting to construct a theory and reconcile with that theory observed facts, and it has not yet extended to the point where I feel myself qualified to state from definite experimental data anything in regard to any such difference as I presume you are attempting to indicate.

3007 X Q. 162. Phenol and cresol you know they are soluble frothing agents?

A. Yes.

X Q. 163. And you know that they are present in wood tar oil?

A. Yes.

X Q. 164. And coal tar oils?

A. Yes, I do. I know that from reading; not from analysis.

X Q. 165. Is your knowledge such that you can give me any figures as to the actual concentration that would take place at the surface of an immersed air bubble in the presence of any dissolved frothing agent?

A. No, sir.

X Q. 166. You do not know as a fact that the ratio of concentration is less than one millionth?

A. No, sir.

X Q. 167. You don't know that?

A. No, sir.

X Q. 168. Now, in the presence of a soluble frothing agent what happens to the metallic particle before it meets an air bubble?

A. It probably has adsorbed or concentrated at its surface some of the soluble frothing agent.

X Q. 169. You put that forth, of course, as a theory?

A. As a theory.

X Q. 170. And when that metallic particle meets an air bubble, just what happens?

3008 A. I should expect that some of the soluble frothing agents which had been adsorbed at its surface would adsorb at the air-liquid contact.

X Q. 171. Then what happens to the metallic particle?

A. If the degree of adsorption at the air-liquid contact is sufficient so that the condition that I have represented in my diagram 7 ob-

tains, then the sulphide particle will pass into the layer of higher degree of concentration of the so-called soluble frothing agent and be carried to the surface with the bubble.

X Q. 172. And what holds it there in the rush and swirl of the pulp while being agitated?

A. This surface force of adsorption and the fact *in* that in that particular condition in the pulp the sulphide particle represents the condition of least possible potential energy of the mixture of sulphide particle, soluble frothing agent and concentrate at the surface of the bubble and water.

X Q. 173. What happens to that bubble when it commences to emerge from the pulp?

A. Some of the soluble frothing agent—I suppose you are still talking of these so-called frothing agents?

X Q. 174. Yes, the same ones.

A. Adsorb at the new air surface that is formed because by so adsorbing and by so concentrating it can reduce the energy of the system formed of soluble frothing agents, water and gas.

3009 X Q. 175. And then as that bubble rises up out of the pulp what happens?

A. This process continues as the bubble emerges into the air, at the air surface there is a concentrated layer of the so-called soluble frothing agent, the concentration passing off toward the interior of the film and at the center of the film the concentration of the so-called soluble frothing agent is least and the concentration of water is greatest. From that point on the concentration of the so-called frothing agent increases until at the other gas surface the concentration is again a maximum.

X Q. 176. That is to say, at the outside of the bubble you have a maximum concentration; at the inside wall of the bubble or the inside of the film of the bubble you have a maximum concentration and passing through the thickness of that wall, however thin it may be, you pass through these stages of maximum, minimum maximum? Is that right?

A. Yes, sir.

X Q. 177. And where is the mineral, the metalliferous mineral product?

A. The mineral is wholly within the bubble film.

X Q. 178. That is given as a theory?

A. No, that is an observed fact.

X Q. 179. An observed fact as you showed it to me?

A. Yes, sir.

X Q. 180. But I could not observe it.

A. Perhaps you are not accustomed to working through a microscope.

3010 X Q. 181. Now you have showed it to me with an oil?

A. Yes, sir.

X Q. 182. And that oil was, so far as we saw it there, insoluble oil, was it not?

A. Insoluble?

X Q. 183. An insoluble oil, an oil that had not been dissolved?

A. I should not attempt to so define it from my observation.

X Q. 184. Was that oil partly dissolved, that we saw under the microscope?

A. I think unquestionably so.

X Q. 185. Partially dissolved and partially undissolved.

A. I think unquestionably so.

X Q. 186. What kind of an oil did you use in that experiment?

A. In this particular case?

X Q. 187. In the particular experiment that you showed me?

A. I would have to ask somebody from the Butte & Superior to say as to the oil. The phenomenon to be observed is the same with any oil so I didn't pay any particular attention to the oil that was used. If you care—would you like——

Mr. Williams: I will take the statement of whoever put the oil in.

Mr. Scott: Mr. Dosenbach.

3011 Mr. Dosenbach: The oil was mixture consisting of 70% fuel oil, 18% pine oil and 12% kerosene.

Mr. Williams:

X Q. 188. Endeavoring to put the matter in language not scientific, perhaps, but more understandable to the lay mind: When you have oil, in the flotation process, the oil coats the metal, doesn't it, in the pulp?

A. I think that some of it, some of the metal in the pulp is coated. As I say that question of coating the metal in the pulp is purely a question—I presume you mean before the metal comes in contact with an oil coated bubble?

X Q. 189. We will take that?

A. That is purely a question of chance. You have got a certain number of globules of oil in the pulp, emulsified there, an enormous number, millions or even billions would be needed to express the number. Also if I recollect correctly, a cubic inch of a sulphide subdivided into the size of the ordinary flotation process breaks up into something like three hundred million particles. Now, in a mixture containing millions of oil globules and millions of sulphide particles, the number of probable combinations of the oil globules and solid particles is of course enormous, and there are therefore an enormous number of chances for an oil particle and a sulphide particle to come together. If they do so come together the oil would tend to absorb at the sulphide surface by replacing the water. If, however, one of these particles should miss meeting an oil globule of course it would miss being coated.

3012 X Q. 190. Now, turning to your diagram 7 and to the line that you have indicated CD. In the case of a soluble frothing agent, a frothing agent wholly in solution, to the right of that picture would be water containing soluble frothing agent dissolved in it, wouldn't it?

A. Yes.

X Q. 191. What would be to the left of that picture where you now have oil?

A. The concentration of the soluble frothing agent to the left, and you will recollect that my line CD represented a line somewhere around in here surrounding the bubble, so that there is the so-called oil to the left of this line and the water at the right. The concentration of the so-called soluble frothing agent will increase as the air-liquid interface is approached.

X Q. 192. And the upper of your particles marked "Sulphide" will be where with the soluble frothing agent?

A. There. And in the same position that they are *are* marked there.

X Q. 193. And the thing that shields that metal particle from the air inside the bubble will be where?

A. This. The interface between the air and the liquid, and at that interface the oil will be most wholly—or the frothing agent will be most wholly concentrated.

X Q. 194. And you present that theory without having any knowledge of the amount of concentration that takes place?

3013 A. Yes, sir.

X Q. 195. And as to whether it may be a wholly negligible factor?

A. Well, it is not a wholly negligible factor.

X Q. 196. You accept the term "selective action"?

A As meaning what?

X Q. 197. Oils and metals in the ore pulp.

A. As meaning that the oil has a tendency to replace the water at the surface of the sulphide particle and that the water has a tendency to replace the oil at the surface of the gangue particle, yes, sir.

X Q. 198. Now, suppose we have a pulp in which acetic acid is dissolved?

A. Yes, sir.

X Q. 199. Has acetic acid that same selectivity for metal?

A. It must have if the sulphide particle concentrates at the surface of the air bubble in a way entirely similar to the way in which it concentrates at the surface of the air bubble when oil is used as the contaminant rather than acetic acid.

X Q. 200. And how about the gangue?

A. The same statement must apply.

X Q. 201. That is to say, the acetic acid solution selects the metalliferous mineral for concentration at its surface and does not do so as to the gangue?

A. Whatever adsorbs at the liquid-gas interface, when acetic acid is used as the contaminant, forms there a film which acts with respect to the sulphide in a way entirely similar to the way in which

3014 the oil acts when oil is used if, as I say, the sulphide concentrates at this gas-liquid interface.

X Q. 202. Take such a substance as saponine in solution in water. Will that reduce the surface tension?

A. I do not know.

X Q. 203. Will that adsorb at the surface of the metal?

A. I do not know.

X Q. 204. Where, in your theory, is the selective action of air for metal utilized?

A. It is not utilized.

X Q. 205. Discarded—You discard it?

A. Yes, sir.

X Q. 206. Wholly?

A. Yes, sir.

X Q. 207. Take soap, for example. That dissolves in water. That reduces surface tension, does it not?

A. Yes, sir.

X Q. 208. Does that adsorb at the surface of a mineral when thus dissolved.

A. I do not know. It is not necessary that everything which reduces the surface tension of a liquid and thus adsorbs at the surface and aids in stabilizing a froth will also select a sulphide mineral from a gangue.

X Q. 209. Why not?

A. I do not know. These are experimental facts, that there are certain substances which so adsorb at gas-liquid surfaces will select sulphide mineral from gangue.

3015 X Q. 210. And are both these conditions necessary for froth flotation?

A. First that the—no, it is not necessary that the particle which selects shall also reduce the surface tension.

X Q. 211. But is it necessary that there should be something to select and something to reduce the surface tension?

A. No. There should be something to select.

X Q. 212. Well, what do you mean by that?

A. That there should be present something which will adsorb, or which will cause adsorption at the surface of some substance which will have a selective action for the sulphide as opposed to its selective action for gangue.

X Q. 213. Isn't air such a substance?

A. It may be.

X Q. 214. You don't know from investigation?

A. I don't know that from my own investigation.

X Q. 215. What has been your observation of commercial operations in flotation concentration of ores?

A. I have seen the operation at the Butte & Superior Mining Company's mill and at the mill of the Utah Copper Company.

X Q. 216. During what period?

A. Recently, since I have come to Butte.

X Q. 217. Since the first of the year?

A. Yes, sir, since I have come to Butte.

X Q. 218. And all these operations that you observed were with what general proportions of oil?

A. I do not know. I do not know at Butte & Superior. I do
3016 not know what all the operations were at the Utah Copper. Some of them I know and some of them I do not. They were more or less varied.

X Q. 219. I suppose you would not be able to recognize the difference between large and small quantities of oil?

A. That depends upon how large and how small.

X Q. 220. Well, take below twenty pounds and above twenty pounds—take four pounds of oil to the ton of ore and then 22 pounds of oil to the ton of ore. You would recognize the difference at once wouldn't you?

A. I can't say, Mr. Williams, because my experience with these operations has been, as you see from my answer to the last question, rather small and I would not say. If you will say 200 pounds or 250 pounds, yes; I can tell that without any question.

X Q. 221. Well, suppose we take an operation with two pounds of oil to the ton of ore, one tenth of one per cent. As I understand your theory the oil carries the mineral in the froth, is that right?

A. The froth carries the mineral; and the froth consists of oil and water and air.

X Q. 222. Mighty little oil there, isn't there?

A. Yes. The bubble film, I should perhaps say.

X Q. 223. Have you ever seen the concentrates that come from an operation of two pounds of oil to the ton or less?

A. Not that I know of.

3017 X Q. 224. You are not aware of the fact that the oil has disappeared from sight and touch?

A. No, sir.

X Q. 225. Now, when you announced three conditions which determine the amount of oil, the amount of the sulphide mineral, the amount of aeration and the dilution of the pulp, did you base that upon a study of recent operations such as you have described?

A. No, sir; that was based purely on reasoning, and, as I think I stated previously, some outside confirmation in mill practice, in the figures presented previously. I have not yet had time to go through those sufficiently thoroughly to make that an absolute statement, but the figures tend in that direction. It is very hard, as I think I said before, to sort such conditions out in mill practice, due to the fact that one of two conditions, or two of them, may be operating at the same time, and it is hard to segregate one from the other; but in such cases where two of the conditions do remain constant over any period, then the third is very plainly the determining factor in the amount of oil necessary.

X Q. 226. As a matter of fact you put those forward as theories which seem reasonable to you?

A. No, I put them forward as explanations—as predictions of what must occur, from observation of other observed phenomena.

X Q. 227. But they have not been subjected to the acid test of study of those conditions in the manner in which they should

3018 be studied before you could put them forward as rules?

A. Carrying all things constant and varying one of them, you mean?

X Q. 228. Yes.

A. No, I have not.

X Q. 229. You said in one of your answers that acid in the froth flotation process tends to adsorb at the gangue particles.

A. At the surface of the gangue particles.

X Q. 230. Did you refer to any particular acid?

A. Sulphuric acid. That is the one principally used.

X Q. 231. Does that imply that there is a reduction of surface tension by reason of that adsorption?

A. No.

X Q. 232. Does sulphuric acid when dissolved in water, increase or diminish the surface tension of the water?

A. I believe that it increases it.

X Q. 233. That is a well known scientific fact, is it not?

A. I have seen it stated recently in some books; I looked it up particularly in anticipation of the question.

X Q. 234. The Chemical Calendar gives that, doesn't it?

A. Yes, I think so.

3019 X Q. 235. A rather remarkable fact, that sulphuric acid, when dissolved in water, increases the surface tension of water, making it a rather unusual substance in that particular, isn't that the fact?

A. I did not read that.

X Q. 236. Isn't it a fact?

A. I don't know as to that.

X Q. 237. Now, in your article, of which I read portions to you; in case No. 2, sulphide gangue, water, oil and acid. You say "The addition of the acid has the two-fold effect of further lowering the surface tension and decreasing the adhesion ratio." That is true, is it not?

A. True reading, yes. I have learned more since that was written.

X Q. 238. That was a mistake?

A. That was a mistake. It will be noticed, I think, if you look at the paper that the lowering of the surface tension by the acid—if you will recollect the experiment here, the question of lowering of the surface tension has not been emphasized as the important factor in the stabilizing of the froth.

The Court: I suppose your science is like law, always something to learn?

A. Yes, exactly, and this is rather a new branch.

Mr. Williams:

X Q. 239. How would you popularly define this viscosity?

A. I think, as the resistance of two adjacent parts, both liquid, to the movement of one part past the other.

3020 X Q. 240. Would tenacity be suggestive of the quality of viscosity?

A. Well, I should think that viscosity with that definition would be a sufficiently definite term to use.

X Q. 241. Would you accept "tenacity" as somewhat illustrative of the quality of viscosity?

A. No. I would much rather use viscosity. Tenacity has an entirely different meaning.

X Q. 242. Do you know the methods that are used or that are perhaps the most usual methods used to measure viscosity?

A. No, sir; I think that one of the subsequent witnesses can probably give you the physical methods.

Redirect examination.

By Mr. Scott:

R. Q. 243. Do you know of any instance, Prof. Taggart, in which a substance which has the effect of raising the surface tension of water understood to produce froth flotation and concentration?

A. In the Potter-Delprat process, which consists in the introduction into a pulp, finely ground, of hot sulphuric acid, and a stirring of that pulp, there arises to the surface and forms on the surface a froth, which, looked at under the microscope, is similar in appearance to the froth which I showed this afternoon; that is, it consists of a liquid film generally within which are the particles of sulphide,
and as far as I have been able to see, those particles are con-
3021 tained as wholly within the film as the particles in this film
that we had here. Sulphuric acid raises the surface tension, and we get conditions that are entirely similar to the conditions to the process using oil. The question, however, will come entirely under the general presentation, that there is some substance present within the contaminated mass which by adsorbing or concentrating at the surface—at the liquid-air surface, lowers the surface tension, and which has the further quality of selecting the sulphide from the gangue. The bubbles then rise to the surface and notwithstanding the fact that those bubbles may have a somewhat higher surface tension than that of water, there is, nevertheless, due to the selective action of whatever the film is at the surface of the bubble, that the sulphide particles—There is present a film of solid matter which is sufficient to stabilize that mass long enough to allow the froth to be removed from the machine.

R. Q. 244. Can you draw any inference regarding the relative importance of the powdered ore and the liquid frothing agent as a stabilizing substance from the fact that this Potter Delprat process can be carried out, notwithstanding the raising of the surface tension of the water by the reagent used?

A. It is my opinion that the stabilizing by means of the solid matter is by far the most important part of the process of stabilizing.
I think that was well represented in the experiment this
3022 morning in which you saw that with plain water, at the
water-air interface, the solid matter stabilized the film and made it act approximately as a solid, while at the air-liquid surface, when the solid matter was absent, and yet some of the soluble agent was present, there was no such stiffening of the film as to cause the surface to act approximately as a solid.

R. Q. 245. Could you tell a bubble film of the Potter process from one formed with oil, by examining them under the microscope?

A. Not if the oil was used in very small quantities. As you increase the quantity of the oil, of course it becomes more visible in

the bubble films, and then you could; but I used in the particular experiment to which I referred, a galena-limestone ore from Joplin, Missouri, some small quantity of blende being present, and in that particular ore—working on the Potter-Delprat process, and working with a small quantity of oil, as limited a quantity as I could use and still get froth, and I did not measure the exact quantities—Then I could not tell the difference between the froths. It is not true that I had them presented to me, one and the other, without my knowledge as to which they were and attempted to tell the difference; but with the knowledge of the facts before me I could not distinguish any difference.

R. Q. 246. If the oil were used in something above the minimum quantities, would it be by reason of any difference in the
3023 structure between the oil formed froth and the Potter froth that you would distinguish them, or merely by your ability to see the oil as oil?

A. I think merely by my ability to see the oil and see the possible play of colors at the bubble surface, due to oil contamination.

R. Q. 247. As far as the structure of the film and the nature of the film goes, would there be any difference between the two, even though a large amount of oil were used?

A. No difference in character; merely the difference in the thickness of the oil layer.

R. Q. 248. I think this morning you stated, and also this afternoon, that it is not essential to this process that the sulphide particles be coated with oil; that they are very likely to become coated with oil, but that it is not essential, and you stated that—I am not sure whether you stated that it was not necessary to pre-agitate before sending the pulp to the Spitzkasten or to the machine provided with the Spitzkasten; but in view of that statement I will ask you why it is that they usually agitate it before sending it to the Spizkasten?

A. I think there are two reasons probably. If you do not pre-agitate, then you do not get the emulsification previous to the passage of some of the pulp into the Spitzkasten—That is, you do not get as great pre-agitation as where you use a couple of preliminary agitators before the separating process. The result of the
3024 lack of such pre-agitation is that some of the oil in the pulp, which has not yet been taken up by bubble surfaces, floats and is therefore lost to the process; and furthermore, to get as complete aeration and give as good a chance for the sulphide particles to pass into the froth, were you not using this preliminary agitation, it would be necessary to add one or more Spitzkasten and agitators to the regular flotation machine. There are those two things, and probably the more important factor is the one of conserving the oil,—not wasting it on the surface of the first Spitzkasten.

Recross-examination.

By Mr. Williams:

R. X Q. 249. I don't think that you have described the oil bubble carrying metal particles as it is above the surface of the liquid.

A. I attempted to, sir; I said that we had at the interior of the bubbles, air; surrounding that a liquid film, composed, in the case of the oil bubble, of oil and water; that at the air-liquid contact—and I speak here of the air within the bubble—there is a concentration of the oil—a high concentration of the oil, and as you pass toward the center of the film the degree of the concentration of the oil lessens and the degree of concentration of the water increases, until at the center of the film the water is at its maximum concentration. Passing from that point outward, the degree of concentration of the water lessens and the degree of concentration of the oil in-
3025 creases to the outer air-liquid interface, where the oil concentration is again a maximum.

Re-redirect examination.

By Mr. Scott:

R. Q. 250. One more question. Have you made such a study of the Potter-Delprat process as would enable you to advance an explanation of those processes corresponding to the explanation that you have given of the oil process today?

A. Well, I should say that the explanation was absolutely the same, except that I do not know what the particular thing is which concentrates at the air-liquid contact, and which has a selective action for sulphide mineral as opposed to the gangue. We suspected, when we first started, that that thing was a case of gas attachment to the particles, and we were very much surprised and rather dumbfounded at first when we examined the films under the microscope and found that they were, in as far as we were able to distinguish, the same films that we had been obtaining by the use of oil—in appearance.

R. Q. 251. You have never ascertained, then, what it is which brings about this selective action?

A. Not apart from the fact that the system tends to arrange itself—and this is of course good physics—in such an order as to present the least energy—as to have the least potential energy.

3026 Re-recross-examination.

By Mr. Williams:

R. X Q. 252. Are you sufficiently familiar with the history of the subject to know that the Potter process won't work with slimes?

A. No, sir.

Witness excused.

Professor FREDERICK E. BEACH, a witness called on behalf of the defendant being first duly sworn testified as follows:

Direct examination.

By Mr. Scott:

Q. 1. Please state your full name.

A. Frederick E. Beach.

Q. 2. Will you please state your qualifications for testifying upon the subject now before the court?

A. Well, I was educated at Yale University, and my undergraduate course was as a student of mechanical engineering. After graduation I spent four years, part of the time as an apprentice and part of the time as a journeyman machinist, and then for a few years I was a draftsman, and after that I returned to Yale University as a graduate student, and after three years' study received a degree of
3027 Doctor of Philosophy, and since that time I have taught there, and my present position and title is Assistant Professor of Physics in Yale University. My teaching has been, with very slight exception, in the department of the university known as the Sheffield Scientific School; that is, the scientific department of the university as compared to the classical department.

Q. 3. About how many years has your connection with Yale University as an instructor or professor covered?

A. As I remember it, I have had charge of class-room instruction—not as a mere laboratory assistant, but as a classroom instructor, since 1891.

Q. 4. I presume considerable of your time is given to research, as well as instruction?

A. No, not a great deal; my occupation has been more particularly with the teaching functions than with research.

Q. 5. Have you any connection with mining operations or mining interests?

A. No; personally, none.

Q. 6. How did it happen that you became interested in this flotation concentration process?

A. Well, it was a matter of conference between the different departments. The staff—the Faculty of the Hammond Mining Laboratory, that is, the so-called mining department of the university, had this problem there, to teach flotation, and flotation processes of
3028 mineral separation; and as no accepted explanation had been given, and it was regarded as more or less of a mystery, a request was sent over to the Physics Department, the Sloan Physics Laboratory, for some collaboration on a work of investigation to see if we could find out what the explanation for this particular phenomenon was.

Q. 7. Did you make some progress in that investigation?

A. Why, yes; after studying it for a number of months—I don't recall just how long, but 6 or 8 months—we felt satisfied that we had a true and satisfactory explanation.

Q. 8. Can you summarize the points in the theory you arrived at?

A. Well, stated in a very popular way, it might be something like this: To take examples of familiar separation: Suppose, for example, that you had particles of finely divided gold held more or less in suspension in water. Now, it is known that mercury—quicksilver—has a selective action on gold; it is popularly said that mercury wets gold. As a matter of fact, gold is soluble in mercury, forming what is called an amalgam. So that, to make a sort of hypothetical separation process, imagine that we had a lot of small mercury particles falling down through a pulp consisting of water and suspended gold particles; as these mercury globules touched these gold particles, the gold would stick to the mercury and would be carried down to the bottom. Of course there is not any such
3029 actual process carried out; the actual selection of the gold particles by mercury is carried out in a different way practically, in the amalgamation process.

Now, to continue our imaginary picture, suppose that these little globules of mercury were blown full of air, so that they were mercury bubbles, and suppose that they were let in at the bottom of the vessel, they would rise up through the mass, the little sheets of mercury on the outside of this bubble coming in contact with the gold particles would carry them up. We should have the elevation of the gold amalgam to the top of the surface. That is a picture that we could have in our mind of how we could separate gold by the aid of the selective action of mercury.

Now, we have a somewhat similar case in regard to sulphides and oils. It is known—I think it is acknowledged by everyone—that oil wets sulphides—and when I say sulphides I mean in general, metallic ores, or ores having metallic lustres; I do not specify sulphide as a particular case—Oil wets sulphides, and the sulphides adhere to the drops of oil. Suppose we took an amount of dense oil and let it fall down through a pulp, which is water containing a lot of sulphide particles in suspension, and that these drops of oil were heavy enough—I mean if the density of the oil were near enough to unity, or a little more than unity—as they dropped into the water surface they would fall a certain distance, and as they fell down, if
3030 they came in contact with any particles of sulphide they would carry them down to the bottom of the vessel, provided the density of the oil was greated than the density of the water. This is the analogy of the mercury drops carrying the gold down.

Now, to reverse the case, suppose we take out the interior of the little drop and fill it with air so that it is a kind of balloon except that the envelope of the balloon is oil or an oily film, and allow these oily balloons, so to speak, to rise up through this pulp to the surface. The sulphide would be above the surface, it would be elevated by these little balloons to which they stick. Now, that is the mental picture that we formed of what actually happened in the flotation cell, after we had examined the process. Of course that does not account for all the details. I have it in mind a little bit later to point out the accepted scientific principles which bring all the processes of the flotation cell into harmony with the accepted facts

or principles of physics. That is just a preliminary sketch of our idea of how flotation occurs.

Q. 9. Would it be in line with your plan of explaining this to state the particular principles or facts that you established?

A. In order to explain how this thing comes out or occurs it would be necessary to establish on an experimental basis certain facts: first, the fact of the selective adhesion of oil to a metallic or sulphide particle; second, it would be necessary to establish the existence
3031 and variation of surface tension; thirdly, we ought to establish the fact or the essential condition for a standard bubble film. These are essentially experimental facts. Now, fourth, we will make use of what is called the principle of minimum potential energy. The potential energy of a system tends to a minimum. In order to have a satisfactory explanation which would be accepted by the scientific world, these facts must be established. The principle, I suppose, is not subject to question.

Q. 10. How do you proceed to demonstrate the selective adhesion of different liquids for a solid? And, if I might make a suggestion, if it occurs to you as we go along, I suggest that you make use of the simple experiment that we started with, whenever an analogy occurs, I think it would help us; that is to refer back to the mercury bubble or the oil bubble whenever occasion arises.

A. Well, we are presented first with the question: Do different substances behave differently toward each other? Does one liquid wet a substance more than another liquid? And is there any way of making this quantitative? That is, I mean is there any way of saying that one liquid wets another twice as much as the first? That is the first problem that presents itself to me. In the flotation cell there is evidently some difference in the action of the liquids involved on the sulphide than that on the quartz. Now, can we exhibit or demonstrate in any way, apart from engineering processes,
3032 commercial processes, the fact that these liquids do behave differently with respect to these substances? Will one—we will resort to some very simple experiment. Take a perfectly clean plate of glass and put on it a drop of essentially pure water. Instead of this drop standing in a heap, it will flatten itself out and spread for a very considerable distance from the point which was initially touched. Now suppose you take the same water or a drop from the same sample of water and put it on the leaf of a familiar vegetable, cabbage, it will be observed there that this drop does not seem to spread out. In popular language without any attempt to make this a quantitative statement, one might say that water wets glass but does not wet the waxy vegetable surface. That, however, is not quite satisfactory to the physicist. He wants to know: How much does the water wet the glass? Twice as much as it does the cabbage leaf? Or is it 100 times as much? I do not know of any book in which that answer has been provided. Another familiar example of the selective action or a selective adhesion of liquid for solids can be seen in the case of mercury. If a drop of mercury is placed on the surface of glass, if the drop is relatively small, it will gather itself together in a globular form. If a drop of mercury is put on a gold watch case, the

mercury will flatten itself out and spread over very much as the water did on the glass surface. There is evidently some intimate and essential difference in the behavior of substances with respect to
3033 each other. In popular language it is said that mercury wets gold but mercury does not wet glass. That is not very satisfactory. In fact it is not altogether true and if the court would permit me I would like to show a simple experiment which will—I mean I would like to draw a figure to illustrate a simple experiment which I have often tried before classes to indicate that mercury does wet glass. It is simply a question of degree and not a question of difference in kind. Suppose that represents a horizontal surface of glass and you take——

Q. 11. (Interrupting.) Professor, might I suggest that as you go along you letter everything so that when we have it here we can follow your illustration?

A. "G" represents a horizontal glass surface. And if we put upon that a drop of mercury ("M") that mercury will ultimately assume a shape something like that (indicating). I intended that the upper surface should be level. The thing to which I wish to draw attention is that at the point which appears to me the point of contact of the mercury with the glass, the tangent of that curve makes an angle between the glass and the tangent of roughly something like 135 degrees. I do not mean to say that it is always that, but it looks something like that. This angle on this side might be 45°. Now, suppose we vary our experiment indicating the contact of mercury and glass in this way. Suppose we take a tube and on the end of
3034 that tube we blow a little glass bubble or sphere (S). "T" represents the tube of glass; "S" the sphere which has been blown at the end of it. We will assume we make use of the convex surface of glass. Now, suppose we lower that down until it touches a horizontal surface of mercury. "H" is the horizontal surface of the pool of mercury (M). Externally it will be observed that this mercury surface is not level, as we get very close up to this sphere, but that it will rise above the hydrostatic level of the mercury, and we shall have the condition of things which was really present here, namely, that the angle between the tangent, the liquid surface and the tangent, the glass surface is again something like 135°. That is to say, the same condition of things occurs there as occurs here. But when you look at this diagram with the mercury rising up to meet the glass you will be convinced—when you look at that I say you will be convinced that mercury does wet glass. It sticks to it, adheres to it. Otherwise, it would not rise above its horizontal level. So, it is not true to say in such broad language that mercury does not wet glass. It is simply a question of degree, how much it wets it. Now, that is the first problem that is presented to us to find out how much these different liquids, oil, water, alcohol, acetic acid, other things, wet sulphide compared to the amount which they wet quartz or calcite or other gangue materials.

Q. 12. Before we forget it I would like you to mark the
3035 diagram. You might mark it diagram No. 8 with your initials.

(Witness marks diagram.)

Mr. Scott: We offer this diagram in evidence.

Mr. Williams: No objection.

Diagram admitted in evidence and marked Defendant's Exhibit 131.

Whereupon an adjournment was taken until 10:00 A. M. Thursday, April 26th, 1917.

Thursday, April 26th, 1917.

FREDERICK E. BEACH resumed the stand for further

Direct examination.

By Mr. Sheridan:

Mr. Sheridan: If the court please, I would like to make a request this morning. We have some lantern slides of those pictures showing the different forms of bubbles and different froths with different varieties and kinds of oils. Now, it is not going to be very agreeable to show these in the daytime, either to the court or counsel; and if the court will give us an evening session, any evening, beginning, say at eight o'clock, it will probably take an hour and a quarter to an hour and a half to show them. I think it will be very instructive.

3036 A photograph looks flat while a lantern projection will look very clear. We want to offer them in evidence, but we would like to show them as we offer them.

The Court: What are these?

Mr. Sheridan: Lantern slides of those photographs you saw. We have the lantern and the slides. Any evening that will suit the court and counsel.

The Court: All right, some evening before you get through.

Mr. Sheridan: Most any evening. We can make it tonight or tomorrow night or any evening that will suit you.

The Court: Well, unless you have some special reason, next week.

Mr. Sheridan: No, no special reason.

Q. 13. Now, Professor Beach, if you had not finished, will you kindly continue?

A. I was discussing at the close of the session, some methods by which we could judge quantitatively of the degree of wetting of a solid by a liquid. Now I satisfied myself that if we put a drop of a liquid upon the clean surface of a solid, the way in which this drop heaps itself up is an indication of its degree of wetting. If I may have a sheet of paper on the blackboard I will endeavor to illustrate what I mean. Suppose that that represents a clean surface of aluminum (Al.) and suppose by means of a medicine dropper you put upon that a small drop of water. By "small drop" I mean two or three millimeters in diameter. Then I find that that drop heaps

3037 itself up in some such way as that and the angle between the tangent and the surface of that side of the horizontal meas-

ured around there, this angle in most of the text books is called the angle of contact; but if you will permit me we may perhaps change that designation here. Let us call it the angle of repose. This is a heap of water and it finally seats itself so that it has a certain angle toward the horizontal surface. I find by referring to my notes of some measurements that I carried out upon this, that that angle, call it "theta" was 85°, with a variation either side of something like 1°. This was water and this was an aluminum surface. I tried a similar experiment, putting on it a drop of oil, for example oleic acid, and in that case——

Q. 14. Will you mark that "Oleic acid" please?

A. (The witness marks the word "Oil"). In general a drop of oil does not heap itself up in the way that the water does, but flattens itself out. I do not happen to have in my notes exactly what that angle was, but it was very small. Now, we judge of the degree of wetting, or the intimacy of the contact, the adhesion of the oil to the aluminum compared to the adhesion of the water to the aluminum by this angle that I have called the angle of repose. So here, we have a way of testing or examining what has been called the affinity of the liquid for the solid or the degree of wetting of the solid by the liquid.

The Witness: I would like to call now for the chart which Professor Taggart showed in his testimony yesterday.

3038 Q. 15. Are you through with that chart there; if you are, kindly mark it "Beach diagram No. 9".

A. I have marked it "Beach diagram No. 9".

Mr. Sheridan: I offer the diagram in evidence.

Diagram No. 9 admitted in evidence and marked Defendant's Exhibit 132.

(Taggart diagram No. 3, defendant's exhibit 126, handed to witness).

The Witness: In the experiment which was shown to the court yesterday and of which this is a diagrammatic representation, we observe that the oil heaped itself up; that there was a very small portion of the surface of the quartz in contact with the oil, the oil being immersed in water; on the contrary, there was a considerable degree or area of contact with the oil and the galena. Here we have, then, of the principles which I have enunciated, experimental evidence, using different substances, different kinds of gangue, different kinds of sulphide and different kinds of oil, a means of judging how good this oil is in selecting the galena, and how good the quartz will be in rejecting the oil that is setting in the water. I will return to this discussion after having announced and explained certain other facts. This was the first one of the three facts which I propose to discuss, namely, the selective adhesion of a liquid for a solid.

Now, the next fact that we need to consider is the question of surface tension, the existence, and the possibility of varying surface

tension. Every liquid surface behaves as if it were under
3039 tension; it behaves in some respects like a stretched elastic membrane; this, however, is only a way of looking at it. The thing that we actually observe is that when the constraints are removed, the tension is relaxed. It is merely a mental picture. We do not say it is actually under tension, but it behaves as if it were under tension. This is a well known and accepted and undisputed fact.

Now, I want to introduce another way of looking at this phenomena. I want to show that every square centimeter of any surface has associated with it a definite amount of energy, which is numerically equal to the surface tension, and this will be a little more helpful way of viewing the phenomena for our purpose. Consider any body, and imagine that it consists of two parts. Those parts are not separated at present; those are tied together and held there by very strong forces. It would take a pull of many pounds to separate those two parts of the body. Those forces are called the forces of cohesion; in other words, in order to separate those by pulling them apart, we have got to do a considerable amount of work upon the body. Now, after those parts have been separated, that energy is regarded as residing in the body in the surface produced by separation; for, if we were to bring these parts together close enough, in sufficiently intimate contact—not experimentally, but theoretically, they would unite. In the case of certain substances
such union does take place. I am told that in shipping fine
3040 plate glass it is quite necessary to have sheets of paper or something between them; otherwise they are likely to weld together under the influence of the pressure. If we were to take two flat surfaces of lead and push them together, even with my hands, the cohesion would be shown to a certain degree, and I would have to pull a small amount in order to separate them again. I simply have got back a certain amount of this energy if I allow the surfaces to reunite.

Now, another way of looking at that is this: that whenever we produce a new surface, we have added a certain amount of energy, and when we allow that surface to disappear by a complete union, we get the energy back again. It is not very obvious in the case of solid bodies, but in the case of liquid bodies it gives rise to important phenomena, the phenomena of surface tension.

Now, I want to show that the measure or the numerical value of surface tension is numerically the same as the surface energy, and in order to do that, I will draw another diagram. Suppose I have two parallel wires. One of these wires I will designate by the letter "M" and the other wire by the letter "N". Suppose I put across the first pair of wires another wire which I will designate by the letter "R". Now, suppose that I put, up close to this wire, a fourth one which I will designate by the letter "S". Now, upon these two wires which are practically in contact, suppose I put a soap solution,
so as to form a film between those two wires and then, taking
3041 hold of the wire "R" and the wire "S", I separate them by a certain distance, which distance I will call "L". In order

to do that, and in order to hold that in this position which it is to retain here—this rectangle being covered over with a soap film, and the soap film tending to contract—in order to keep this film stretched I must exert in that direction a force, which I will call "F".

Q. 16. Will you letter that wire which you have last indicated?

A. *S1*. The new position of the wire "S" is called *S1*. You must exert on the other edge of this film an equal force, F. We will also, if you please designate the distance, between the wire M and the wire N, that is the breadth of our soap film, by the letter b. In stretching out this film we have done a certain amount of work which we may write in this way, "W". W represents the work done by the force F in moving the wire S from the position S to *S1*, and the work done is the force F multiplied by the distance 1, which the wire moved. Now, consider the area which was inclosed there. The area of this film, the length 1, multiplied by the breadth b. But in a solid film we have two surfaces, an upper surface and a lower surface and each of these liquid surfaces has a liquid tension so that the total area involved in this particular experiment is the area of our surface 1 x b, and the same area below. So, in order to get the work done per unit area of all the surfaces involved we must divide by 2A and, substituting the value of A, we have F1 divided
3042 by 2b x 1, or cancelling out the letter 1, we have F over 2b. That is to say, the force required to maintain this film stretched, divided by the total length of the film involved, which is the length b on the top side and the length b on the lower side. Now this force per unit is what in all text books is called the measure of the surface tension and will be designated by the lettter T. This very simple equation shows that the work done per unit area is numerically the same as the surface tension. Then in an ordinary soap solution, a fairly dilute soap solution, I suppose that the surface tension is numerically about 27 dynes per linear cm. and that numerical value can easily be stated as 27 ergs per square centimeter. So, according to the kind of problem that we are discussing we may either think about the forces that are involved or we may discuss the amount of energy which is associated with both areas of the surfoce.

Q. 17. Will you kindly mark that diagram "Diagram No. 10"?

(The witness marks the diagram "Diagram 10.")

Mr. Sheridan: We offer the diagram in evidence as Beach Diagram No. 10.

Mr. Willims: No objection.

The diagram was admitted in evidence and marked Defendant's Exhibit 133.

The Witness: I would now like to state one or two facts in
3043 regard to surface tension or interfacial tension, that this tension depends upon the nature of the substance on either side of the interface; depends upon the temperature; it is the same in all directions in the surface; it is independent of the thickness of the film when that thickness exceeds a certain minute value. Now,

if we may return again to the relation of the drop of oil upon sulphide and a drop of oil upon quartz we could get some interesting and important relations which will be used in further discussion. Let us consider first the drop of oil upon the sulphide. This horizontal line will represent the upper face of sulphide. Suppose that we place upon that sulphide in the presence of water, a drop of oil. Suppose that this region here represents water. These are the conditions of the experiment as they were tried in the test yesterday. Consider that point which is just at the edge of the drop of water in the water. There are meeting there three surfaces or boundaries, the sulphide—oil surface, and in that interface there is a different amount of energy or interfacial tension which I will represent by an arrow and I will letter it Tso. That means the tension in the boundary between the sulphide and the oil. In the water-oil interface there is another tension which I will designate as Tow. In the boundary between the sulphide and the water at this interface there is another surface tension which I will designate by Esl, which subscription one refers to the medium immediately above the

3044 sulphide. Now when that drop has come to rest that particle may be regarded as in equilibrium under the action of three forces. If we call this angle of repose here by the letter theta, then the position of equilibrium may be written in this way, that the pull toward the left, which is represented by Tsl is equal to Tso—Tow times the cosine of theta. The cosine of theta giving merely the horizontal component of this force. Now, looking at this equation, Tsl is necessarily greater than Tow, because 2sl is equal to Tso plus something else. In other words, the surface tension out here is larger than it is at that point. In other words if we could, in any way, cause that surface tension to diminish then this point would be drawn farther and farther out. Then we see the degree of intimate contact of one liquid for a solid means a small interfacial tension. These are conditions which we have in the case of the oil upon the sulphide, discussed in terms of the force. Now I have shown that these tensions are the same thing as the energy associated with each unit area. By the principle which may be discussed further I have stated the potential energy of any system tends to diminish. We have here a relatively larger surface energy than that there. Now, by cutting out some of this surface we diminish the surface energy of the system, so in this particular case the area covered by the water, viz., Asl tends to diminish with respect to the area covered by the oil

(Aso). Our experimental facts have now been stated in

3045 language which will be very useful to us. When you put a drop of oil upon sulphide under water, the area covered by the water tends to diminish; the area covered by the oil tends to increase.

The Witness: Now, obviously, if we are using small particles of sulphide, the greatest possible area that can be covered by the oil, of sulphide, is when the body is within the material of the oil.

Here, then, we have stated in definite scientific language a fact which is illustrative of the flotation process, namely, that the sul-

phides tend to bury themselves within the material of the oily substance.

Now, suppose we apply this same reasoning to the drop of oil on the quartz. I will number that diagram "Beach diagram No. 11."

Mr. Sheridan: We offer in evidence the diagram marked "Beach diagram No. 11."

Said diagram admitted in evidence and marked Defendant's Exhibit 134.

The Witness: Suppose next that we illustrate the case of the drop of oil upon quartz. This horizontal line which I have drawn represents the upper face of the quartz surface. In the experiment yesterday a drop of oil was seen to take a shape something like this. This medium above it and outside of the oil is water. We go through precisely the same steps of reasoning as before, considering a particle of oil at that point. The angle which I have called the angle
3046 of repose—the angle of the tangent at that point that it makes with the horizontal surface, in this case I will designate that as phi. Here we have a tension between the boundary of the water and oil called Tow. In the boundary between the quartz and the liquid above we have another tension represented by the letter Tql; and at the boundary between the quartz and the oil we have another tension, which I will designate Tqo. These three forces I will shade so as to make them clearly conspicuous. The difference of equilibrium between these three forces is this: Tqo is equal to Tql plus Tow times Cos. phi, from which we draw the important conclusion that Tqo is greater than Tql, because it is equal to Tql plus something else.

Now, as the surface tension is the same thing as the surface energy, we see that the surface energy of the oil-quartz surface is greater than the surface energy of the boundary between the surface of the material Q and the region which I have called 1. Now, as this potential energy tends to a minimum, the surface having the greater potential energy will tend to diminish; in other words, the area of the surface Qo will tend to diminish with respect to the area Q1; that is to say, this drop of oil, when it is put on a quartz surface tends to draw in together; it is as if you had the water surrounded by an elastic skin; the greater the tension there is in this lower surface, the more it will gather it in together. It is the contrary or converse case to that we had before, where you diminish the
3047 tension of the surface and the thing tends to let go or spread out.

We have now established these two things, that the area of a quartz-oil surface tends to diminish; that the area of sulphide-oil surface tends to increase; in other words, if you have particles of quartz in the vicinity of oil and water, the water surface grows larger and the oil surface grows smaller; that is, the quartz finally takes up a position within the water. Similarly the sulphide takes up a position within the oil. This thing was stated yesterday by Professor Taggart, and after having marked this diagram I will

ask if I may again refer to his testimony, using the diagram which he put on the board.

Diagram last marked Beach diagram No. 12.

Mr. Sheridan: I offer Beach diagram No. 12 in evidence.

Diagram admitted in evidence and marked Defendant's Exhibit 135.

(Defendant's exhibit 130, diagram 7, handed to witness.)

A. Professor Taggart's diagram represents a vertical boundary between oil and water. This particle is one of sulphide, and this particle is one of gangue. Now, by the principles which I enunciated and rested upon a secure experimental and rational foundation, lead exactly to the results as stated yesterday. The
3048 surface energy of that portion to the left of the line "CD"——

Q. 18. The portion of what, professor?

A. The portion of sulphide in contact with the oil—has a smaller surface energy than the sulphide in contact with the water. Now, by the principle of potential energy, it tends to a minimum. When a particle is wholly immersed in oil, the total surface energy is less than when it is partly in oil and partly in water. Similarly, in a particle of gangue, the surface energy of the tension of the gangue to the left of "CD," namely that portion wet by the oil, has a larger surface energy than the portion of the gangue to the right of "CD," namely that portion which is wet by the water. Now, since the total potential energy of this system tends to a minimum, the gangue will move towards the right or into the water. Here we have shown how the selective wetting by liquids of different solids may result in their differential separation in the presence of water, oil or other selecting agents.

I mentioned there were three facts upon which my explanation of mineral flotation in the agitation froth process is based; the three facts are the selective adhesion of the different substances, the existence and variation of surface tension. I have discussed the existence of surface tension, and I wish now to say a word about the variation of the surface tension. In the experiment shown by Professor Taggart in which a drop of oil was placed upon the clean surface
3049 of water, a neighboring chip—I mean a chip at a point near to the point upon which the drop of ore fell—this chip was seen to jump sidewise, indicating that where the oil touched the water there was a considerable diminution of surface tension, due to the concentration of the oil, or absorption of the oil at the surface. This variation of the surface tension certainly plays some role—a fairly important role—in the production of stable films. I think I had better discuss that in order to make it clear, by the aid of a diagram.

Suppose we take a chemically pure substance—say, water as pure as we can get it, even though we have a film of water upon a wire ring, or even if we have a bubble on the surface of the water, it only lasts for an instant. If we use water which has been contaminated,

which contains something different from the water, we can produce a bubble or a film which will last for a long time. I wish to explain how this is brought about.

Suppose that these lines represent a thin film of water bounded by air on either side. Suppose that the film is held at the top, and that a certain small force or weight was applied at the bottom, which I will call "F." If this force "F" is less than 75 dynes per centimeter, then the surface tension or the tensile force of this film would at least theoretically support the weight. If, however, the downward pull was greater than that, the film would stretch, thereby becoming thinner and thinner. Now, suppose that the thickness exceeds a very minute limit, there is no change in the tension of the
3050 surface. If we are to have a water film upon a ring, and hold it in a vertical position, under the influence of the weight, the water would gradually drain down toward the bottom, the upper parts of the film would have to support a greater, gradually increasing weight, with the result that it will gradually thin out a little more and more. There is nothing to prevent this thinning; there is no counter balancing force greater than the surface tension, and the thinning is soon brought down to the point where the bubble film will break. It is a very homely illustration, but it is very much like taking some soft gum, like chewing gum, and pulling it down; it stretches out, and as the cross section of this thread becomes thinner and thinner, finally it breaks. Now, in order to get a stability in a condition of this sort, we must have something different. I hold in my hand an elastic band. Now, suppose I stretch that elastic band. As I pull it down it becomes thinner and thinner. But I also notice that the force of restitution, the elastic force of the band, becomes greater and greater. This is the so-called Hook's law of elasticity. In proportion as the force acting upon the elastic body produces a greater stretch, by so much does the force of restitution increase. So that, in the case of this elastic band, if I hang on it a weight, it will settle down to a certain place, where the backward force, the resilience, or the force of restitution of the elastic band is equal to the weight. Now, how can this happen in a film of any sort? Say a film made with a soap solution. Let this portion
3051 of the diagram represent a film made of soap solution. Suppose now that we stretch this film out; what will happen? Well, it is first necessary to assert that whereas the surface tension of the pure water was about 75 dynes per centimeter—I am speaking in round numbers—that the soap solution, under exactly the same conditions of temperature and surroundings, will have a value of only about 27 dynes per centimeter. Soap—the particles of soap when they get into solution or mixture in the water affect the surface tension; they tend to diminish the surface tension; that is to say the surface energy of the soapy water is something of the order of one-third as much as that of pure water. Now, as this potential energy tends to a minimum, the more soap that you can get—the more particles of soap—I mean microscopic or molecular particles of soap that you can get into this surface layer, up to a certain limit, the more will the surface tension diminish. Now, that diminishes

down to about one third of its initial value for pure water, and there the process no longer proceeds further. So we start with a film which has less tendency to contract. We have a strong contractile force in pure water and a much feebler contractile force in soapy water. Now, that of itself will assist in the durability of the film. The stronger the surface tension the more difficult it is to make a bubble. For instance, it is easier to make an independent bubble of water than of mercury, for the reason that the surface tension of mercury is somewhere in the vicinity of four or five hundred dynes
3052 per linear centimeter. In the first place you can make this film and it will not have so much contractile force. Secondly, the soap which has gone into the solution tends to increase the viscosity; the mobility of the film is less; the particles of the film do not move with respect to each other so rapidly; but more important than all is this, that we have a means here, just as we had in the rubber band of stiffening the thing up when it gets too thin. Suppose that I represent by these dots little particles of soap which are in that region; suppose that there were ten of those dots or particles, to fix our ideas. Now, imagine that I have stretched this upper portion here out.

Q. 19. Will you mark that portion, professor?

A. I have marked it with a small "*a*." Suppose we fix our attention upon this portion, small "*a*," for the soap film, and suppose under the influence of an external force this is being gradually thinned out. I think you see now that these particles which are distributed through that layer, have now been scattered or spread out so that they extend through a longer portion or a larger portion of it; that is, the number of particles in an area "B," equivalent to the original area "A"—that surface is now much less—say five. What happens? When there were ten of those particles there, the surface then—the surface tension then was 27; when I have only five particles there the surface tension returns to a condition more nearly that of pure water. The surface tension will be larger then in proportion as the number of these particles thins out.
3053 Then as your soap film gets thinner and thinner, it has more and more elastic force, just as this rubber band did, and so we have the condition of a stable soap film, which is why a soap film will last so long. I have seen soap films that would last, stretched on a ring, for one or two hours, and I have never seen a bubble in pure water, if I formed it last more than a fraction of a second.

Q. 20. Will you kindly mark that diagram #13?

A. No. 13.

Diagram marked Defendant's Exhibit 136, and admitted in evidence.

I have now discussed sufficiently the three facts, experimental facts of physics upon which the explanation of flotation process rests. If the court please, just for the sake of the label, I might refer to these as the Beach-Taggart explanation, to define it from other explanations. I have shown that different solids have selective adhesion for different liquids; I have discussed the experiments as to the variation

of surface tension and shown the conditions for a stable film. The chief factor, probably, in the stabilizing of a film is the increase of viscosity. Suppose the increase in the viscosity in a solid solution is not relatively great. The chief factor there is the variation of the surface tension, but in some other case, for instance in a Saponine solution, the change in the surface tension is not so much from other water as it is in solid solution, but the increase in the viscosity is very great. The increase in the viscosity of a liquid surface,
3054 due to the presence of fine particles was shown yesterday by Prof. Taggart experimentally. And, if the court pleases, I would like to say one word more about the principle of minimum potential energy which is an important one in the discussion of physical problems. If we are dealing with an elastic band it is very convenient to discuss the forces which are involved. We can see the points of attachment and we can get at the stretched portion to measure this force. But there are certain other cases where it is very difficult to form a picture of this force. For instance, if we have a reservoir of compressed air, we know that the air exerts a certain amount of force upon the containing envelope, but we do not always care to localize the force. We speak of the pressure of the system. If we are dealing with electrical phenomena, if for example I were to electrify a rubber rod, and bring it near a feather or a small piece of paper, we should find that the paper seemed to be attracted to the electrified rod, but we can not see the medium by which these forces are acting. In cases of that sort it is very much better to discuss the energy relations. So, as in the case of compressed air, we do not speak of the force of the air as much as we do of the pressure of the air. So, in dealing with electrical conditions we do not speak of the force as much as we do of the potential energy of the system. For example, in an ordinary trolley system. I do not happen to know what may be here, but in my own home at New Haven, the trolley wire has a certain amount of poten-
3055 tial energy which is greater than the potential energy of the rails by an amount which is called 500 volts energy per unit charge. And we say that the electricity runs from the higher potential to the lower,—body at the lower potential. It is the exact analogy of the pressure of the air in the tank. The air flows from the point of greater pressure to the lower pressure. The air goes from the place of the higher potential energy to the place of the lower potential energy. The electricity flows from the places where it has high potential energy to the place where it has lower potential energy. Now, to top off my conclusion, that is, the discussion of the flotation problem, we are having particles move from the place of greater potential energy to smaller potential energy; so, we have to discuss the specialized or localized force, if we find that in a certain position a particle has less potential energy than it would have in some other place, that is the place into which it will move automatically, or by itself. For that reason we have contaminants adsorbing into the liquid surface: it diminishes the surface energy. It is the reason we have sulphide going into oil or oil contaminated liquid, because the oil has less potential energy when it is so surrounded than

if it was in the water. The quartz goes into the water because there it has less potential energy than it would have if it were in the oily layer. I have thus tried to lay a sound physical basis, facts which I believe are accepted by all students of physics, as the basis for the Beach-Taggart explanation of the flotation phenomena in the agitation cell.

3056 Q. 21. What does experiment 5, sprinkling ore on water, show?

A. It shows an increase of viscosity of the surface layer, including the mineral particle. The portion of the surface which contained the chip was not at all disturbed by the motion of the needle, was not sensibly disturbed by the motion of the needle when there was no powder on the surface. When the powder was scattered over, the whole surface moved almost as if it were a solid body.

Q. 22. What do you mean by viscosity?

A. Well, in popular language, viscosity is internal friction. If I move a book along the surface of the table there is a certain resistance to the motion of the book with respect to the table. In the case of a fluid, when we move one particle of a fluid with respect to its neighboring particle there is similarly a resistance to this motion which is called internal friction and which is a measurable thing and is called viscosity.

Q. 23. Can you illustrate this idea of viscosity in some other way?

A. Suppose we start with a beaker of water and we pour into it some finely divided particles. As we increase the number of these particles which are, we will say, merely mechanically inclosed in the liquid, it takes on a consistency which is more like that of a syrup, it pours more slowly. If we increase the number of these particles more and more we finally get it to a paste, the substance becomes so sticky or so viscous that it may be moulded in

3057 the fingers. A good example of this is putting whiting in oil, which makes putty. Putty is an example of a substance which is very stiff or viscous. It flows under the force exerted by the fingers, but it flows with difficulty and very slowly.

Q. 24. What is your idea or explanation of this increase of viscosity?

A. Suppose we were to take two surfaces of glass—I can do that best by illustration. Let the line A represent the surface of a glass plate. Let B represent the surface of another parallel plate, and suppose that the region between these is filled with water. Now we are going to move these plates parallel to each other. The water clings to glass. The particles of the water which are right next to the glass are practically adherent to it. The same is true on this side. Now, when these plates slide, one up and one down, the particles which adhere to the glass move with the plates. The other particles that are nearby are entrained a certain amount but the particles which are in the middle space, provided that is not extremely small, will be just about as free to move as if they were in a large pond of water. Now, suppose we diminish the distance between these surfaces. I will represent the plates again by position A^1 and position B^1. Now, you see the particles which attached first to A and

also to B are in very close juxtaposition. As we slide the plate A^1 up and B^1 down, the particles stick to A, move with the plate, and those sticking to B move with that plate, but the particles which are in the very small distance in between there more or less adhere
3058 or rub against these partially fixed particles on the plates so that it is obvious, it seems to me, that the motion of the plates with respect to each other are somewhat retarded by the resistance of these particles that rub against each other. There is a true friction between the parts of a liquid, such as water. All fluids show a certain amount of internal friction or viscosity. Now, that is exactly what happens in the case of the paste that I spoke of. If we magnify these particles enough, these *a, b, c, d,* if these represent particles of the powder that we put in the liquid and if the little interstices of these particles are regarded as filled up with water, then it is obvious that the particles as a whole are not very free to move; they are hampered by the adhesion of the particles of the liquid on the faces which are juxtaposed. That, in popular expression, is my idea of why a paste becomes so viscous.

Q. 25. Will you kindly mark that diagram 14 and initial it?

(Witness marks the diagram.)

Mr. Sheridan: The diagram so marked is offered in evidence on behalf of the defendant.

Mr. Williams: We have no objection.

Said diagram was admitted in evidence and marked Defendant's Exhibit No. 137.

Q. 26. Professor, you saw the test No. 3 that Prof. Taggart made yesterday, with the beaker, the red ink and the water and the oil?

3059 A. Yes.

Q. 27. What does that show?

A. I would like to have the diagram that he drew for that, if I might.

Q. 28. It is on the blackboard, Professor, and it has not been offered in evidence as yet.

A. This experiment calls attention to the peculiarities of the bending surface or interface between the oil and the water. That interface is obvious. If you look down on it at a small angle it looks shiny, has almost a metallic lustre; but it possesses certain other properties which are important. It shows that there is something there which is different from the pure oil and different from the pure water. There is, in other words, a transition layer here in which, as I apprehend it, the particles of oil are intermingled or mixed in varying degrees with the particles of the water. This transition layer we call an adsorption layer. There is more or less concentration of the different material at such a layer. On the oil side I suppose that that layer contains some particles of water, and on the water side it contains some particles of oil. The striking thing about this is its viscosity and possibly lower surface tension. This is the fabric of

which the bubble film in the flotation process is made up. Recalling Prof. Taggart's description, when a bubble of air is released it rises by its buoyant effect, it entrains some of the water in the region; it gradually lifts to the surface which bows over as this elevated portion raises still farther. It necks off at the bottom and incloses
3060 some of the colored water. We have inside there, air—we have an adsorption layer of air, water passing from the hole into the water. As we pass from the water into the oil we have another adsorption layer which is almost a skin, if I may use that term, or membrane, out of which we can make bubbles. These rise to the top and this skin may remain intact for a short time and show the reddish color when looking down upon it. But, after a little time on account of the considerable weight that is there dragging it down, that bubble film of the oil-water adsorption layer thins out and breaks and this portion which is sort of like a watch glass or crescent, falls down, will return to the lower surface. Sometimes it will rest on that for a number of minutes before it unites with it. And the distinguishing thing about it is that it does not draw itself together into a spherical drop as the ordinary drop of rain would, falling through the air. It has a very viscous film. And this film is capable of making bubbles. We can fill it full of air, we can fill it full of water, or we can fill it full of oil. I do not know at the moment, but I think I can easily show that we may have that viscous film filled with some water in bubbles containing no air above the surface and we may have that film filled with oil and appearing below the surface. In this connection I would like to introduce if I may——

Q. 29. (Interrupting.) Let me ask a question: Can you show by experiments how the presence of solid particles at an oil-water contact results in increasing the viscosity of the interfacial film at the oil-water interface?

3061 A. I will endeavor to do so. I have here a bottle into which I will pour a layer of water. This is ordinary tap water. In this bottle I will pour a layer of kerosene. There were temporary bubbles filled with water formed there in the kerosene. I will introduce into this bottle an amount of copper—finely divided copper, bronzing powder it is called. I am now agitating this mixture and will allow it to stand for a moment or two and there will be seen pendant a short film, a flattened film which when looked at by reflected light looks as if it were copperplated. When looked at by transmitted light it shows a lacy pattern. This is a bubble film which has inclosed within it a certain number of these copper particles.

Mr. Williams: Just mention that you shook it again.

A. I have again shaken the bottle. I have here a specimen of the same film which is not air formed here in the copper, but which illustrates the great viscosity of that particular film. Now, in an experiment which I have actually carried out here I will call your attention to the extreme viscosity of that film which now hangs in a vertical position and I would like the court, if the court please, to examine it by transmitted light and by reflected light.

The Court:

Q. 30. What is the purpose of this?

A. This is to show how this interfacial film, which is the fabric by which bubbles are made, has its viscosity very greatly increased by the metal particles which have become imbedded into the film.

3062 Mr. Sheridan:

Q. 31. Which become imbedded in the film or the interface?

A. Imbedded in the film.

The Court:

Q. 32. This film hanging down is oil and metal particles?

A. Well, it is the adsorption here. It is the same dividing layer which is seen in this experiment, only it now has been over-weighted so that it hangs down and if your honor will look at it by transmitted light, that is, towards the window, you will be able to see the spaces between the particles, that the film is not completely filled; it shows tracery, lace-work. The film is evidently very viscous, it does not tend to contract as ordinary films do.

Mr. Williams: We would like a specimen of the bronzing powder.

Q. 33. What is that, a powdered copper?

A. I don't know how it is prepared; it is called pulverized copper, which is used by painters for bronzing.

Mr. Sheridan:

Q. 34. Professor, I would like to ask you what you mean by a film? Is the film you are speaking about a film composed by oil in which there are minute particles imbedded, or water in which there are minute particles imbedded, or is it that material, that layer that you call the adsorption concentrate layer between the oil and water face?

A. It is the transition layer, what I call the adsorption layer or adsorption film consisting of particles of water molecules, par-
3063 ticles of air molecules, particles of oil, and in this case it has imbedded in it some particles of metallic copper. If they were blown up into spherical form it would be exactly like the froth which appears in the concentration cells.

Q. 35. And the presence of the particles that formed that copper powder does what, in that film?

A. These particles make the film viscous in the same way in Prof. Taggart's experiment, the ore which was sprinkled over the surface of the beaker made it viscous, tended to move more like a solid body than like a liquid body. Have I made myself clear?

Q. 36. Yes. Now, returning to the mineral agitated froth. What is the function of the oil in mineral separation?

A. I apprehend that the oil serves two functions. It makes this adsorption layer from which bubbles may be constructed and by its selective adhesion to the sulphide particles or, conversely the selective adhesion of the sulphide particles to this adsorption layer, the par-

ticles are separated away from the quartz and brought up to the surface.

Q. 37. Now, Professor, before you depart from this subject I would like to have you give a complete explanation of your test, which we call test No. 12, that you just performed with the glass bottle and copper powder so it will appear on the record.

A. With a diagram?

Q. 38. No, not a diagram. I wish to have you give a com-
3064 plete explanation of it so it will appear in the record. Tell about what you did, materials used, bottles used, and so forth.

A. I selected a glass-stoppered bottle about four inches high, about two inches in diameter. I poured into it a layer of tap water about an inch and a half in thickness, from a wash bottle. I then poured some commercial kerosene from another bottle upon the surface of the water, forming a layer about 1 inch thick. I then introduced into the bottle by the aid of a spatula a small amount of copper powder, known to the painters as bronzing powder, using an amount which would cover about a square centimeter of the surface of the end of the spatula. I then agitated this mixture with the glass stopper in the mouth of the bottle for a few seconds and allowed the material to settle down into its apparent levels. After an interval of a few seconds I again agitated it still further and then noticed——

Q. 39. (Interrupting.) For how long; just state how long you agitated it the second time.

A. Less than ten seconds I think. I do not understand that the time of agitating has anything special to do with it. I then noticed when the fluids had come to rest in the bottle, that there was hanging a web-like structure from the interface of the oil and the water into the layer of water. This is the bubble film matter or the water-oil adsorption layer hitherto discussed. In this particular case it was seen to contain a great number of copper particles. When looked at by reflected light the whole surface appeared as if it were
3065 copper plated. When it was looked at by transmitted light it had the appearance of a cobweb which has been exposed in a dusty place for a long time. The light can be seen through this filmy structure and one can, undoubtedly, if his eyesight is sufficiently good, pick out the individual particles of the material. The weight of this material stabilizes the film so that it has already remained in existence I should think for about ten minutes, hanging as a cobweb from the upper surface and resting on the bottom of the bottle. A slight agitation of the bottle shows that this is a very viscous film.

Mr. Sheridan: If you would like to examine the witness on this test before it disappears you are at liberty to do so as far as I am concerned.

Mr. Williams: No, I don't wish to now.

By Mr. Williams:

X Q. 40. Professor, I would like one further explanation. Is that film or curtain-like structure filled with kerosene or air?

A. Well, I will answer to the best of my knowledge after looking at it since it was formed. It is my opinion that it consists of intermingled particles of kerosene and water, forming the so-called adsorption layer. It also contains imbedded within it some mineral particles—particles of the copper powder, and I am not able to discover, looking at it with the glass, that it does contain any perceptible number of air particles. I do not exclude the possibility of there being some minute particles there, but there certainly are not
3066 enough to float it to any degree, and I have not examined it under a powerful microscope.

X Q. 41. The amount of agitation to which you subjected it was a comparatively gentle agitation, was it not?

A. There was no intention—it was simply to shake the things together. I have not performed this experiment very many times, and I cannot say that a long shaking or a short shaking or a horizontal shaking or a vertical shaking have anything to do with it. The idea is simply to intermingle the substances.

X Q. 42. Now, that oil there does not contain any visible air, does it, as the result of the shaking?

A. I would like to say that the water bottle which I used contained air; the water was not free from air; I presume very likely there may be some small adhesions of air.

X Q. 43. It is a characteristic of Butte water that it contains air for some time, isn't it?

A. It is a characteristic of water under pressure at any time that it contains air. I am unable to say that I can see any particles of air with the power of the microscope which I have in my hand.

X Q. 44. Then that other one that you produced that was done some time ago, there is not any air in that oil there at all, is there?

A. Not in so far as I know.

X Q. 45. The metal is practically all down at the interface between the oil and the water, is it not, in both cases?

A. No.

3067 X Q. 46. First we will take the one that was introduced first?

A. I did not intend to introduce this as an exhibit.

Mr. Sheridan: Well, refer to it anyway.

Mr. Williams:

X Q. 47. It is instructive to examine it anyway.

A. No, it is all at the interface.

X Q. 48. Well, a part of it at least?

A. Well, there is some at the upper surface, I cannot say how much there is there. If you remove the cork you will see that there is some there at the surface.

X Q. 49. There is some of the metal floating at the top of the kerosene layer, and apparently a larger amount—or at any rate a considerable amount of metal floating at the interface, and practically no metal in between the top face of the oil and the interface of the oil and water, that is right?

A. There seem to be no copper particles in the mass of the oil that is away from the surface. There are particles of copper—in this specimen the copper is in the oil.

Q. 50. That is the last test which you made; it has not all settled out probably?

A. It has not settled out; but the copper particles appear at the interfaces; the interface of the oil and the glass, the interface of the water and the oil and the interface of the oil and the air.

Q. 51. I presume you have observed that metal particles
3068 tend to settle to the bottom of an oil layer when that oil layer floats on water?

A. Some of them do.

Q. 52. That is the extent of your observation, is it?

A. Some of them do and some of them may not.

Q. 53. But in your experiment, the one that was done before the court opened, there has been substantially a settlement of the metal particles to the bottom of the oil layer, except for those particles that are floating on top of the oil layer?

A. I think so.

Mr. Sheridan:

Q. 54. Then, just carrying Mr. Williams' question further, the metal tends to go to the interfaces between the two different liquids or a liquid and a solid?

A. The statement of the result I would put this way, that the metal goes into that medium where its potential energy is least.

Now the conditions are somewhat variable. The potential energy of some of the particles may be least at the air-oil surface, in the case of film flotation. In this I judge that the copper particles have less potential energy at this adsorption layer than they have in the liquid kerosene. Some of them, also, have found positions of equilibrium, creeping up the side of the glass jar. Some of them are entangled up at the top of the cork.

Q. 55. Going back to the agitation froth process, is there any difference in the function of the oil when the percentage is less
3069 than one per cent or when it is over one per cent?

A. No; in my opinion no.

Q. 56. Is there any point at which the function of the oil in the mixture undergoes a change, short of the simple bulk oil flotation?

A. None whatever.

Q. 57. Will you kindly state, if you know, or state what your opinion is, if there be any difference between an air froth and an oil froth?

A. I am not sure what you mean by an air froth and an oil froth, but I will try to answer the question. If by an air froth is meant one which is formed with a small quantity of oil, more than a fraction of one per cent—more than one per cent—I say there is no difference between those two froths. Have I apprehended your question?

Q. 58. I think you have answered it all right. As I understand, the only difference there would be between froths formed with a

fraction under one-half of one per cent, and within reasonable limits up to 25 per cent, would be the amount of oil in the froth?

A. A difference in degree, but absolutely no difference in kind.

Q. 59. In what respect does an agitation froth made with a so-called insoluble oil differ from an oil froth made with say a soluble contaminant, such as creosote?

A. It is a difference in degree, and not a difference in kind. The soluble contaminants may be more effective in producing a
3070 foam, and the heavier or selecting oils may be those oils which have a greater adhesive power of picking out the sulphide.

Q. 60. Did you hear Professor Taggart's deposition yesterday?

A. I think I did, most of it; I am not sure that I did all of it.

Q. 61. When he referred to the fact, as I remember it, that whether it was a soluble contaminant or an insoluble contaminant, that the contaminant tends to concentrate at the interface of the air and gas; do you agree or not with that proposition?

A. The soluble contaminant?

Q. 62. Both soluble and insoluble as I understand tends to have the least potential at the interface between the air and the liquid?

A. The soluble contaminant will concentrate at the interface provided that it lowers the surface tension, and the so-called insoluble oils also do disperse and disseminate themselves to a certain degree throughout what we would ordinarily call the solvent, and if they lower the surface tension they will concentrate at the interface.

Mr. Sheridan: Mr. Williams, you may have the witness.

Cross-examination.

By Mr. Williams:

X Q. 63. Professor Beach, you illustrated in diagram No. 11 the force of surface tension at the oil-sulphide, oil-water and sulphide-water surface?

3071 A. May I see the diagram again please?

X Q. 64. Can you give me any measurements as to these forces; take first the force T_{so}?

A. I don't know of any method by which those interfacial forces can be independently measured; there may be some, but they have not been brought to my attention.

X Q. 65. And therefore you have not, as a physicist, succeeded in making any definite expression of those forces?

A. I have not attempted to reduce them to numerical value.

X Q. 66. Is the same true as to diagram 12, wherein, in place of sulphides, you use quartz, and represented again diagrammatically the three varieties of surface?

A. I would say that I am not at present aware of any measurements of interfacial tension between a solid and a liquid. The interfacial tension between two liquids has been measured.

X Q. 67. Can you give me representations in dynes or otherwise of those forces?

A. I may refer to the authorities for that?

X Q. 68. Suppose you do it after luncheon?
A. All right.

Whereupon an adjournment was taken until 2:00 P. M. Thursday, April 26, 1917.

3072 2:00 p. m., April 26th, 1917.

X Q. 69. Now, Professor, can you give me the oil-sulphide tension, surface tension under the conditions shown in your diagram 11?
A. I know of no numerical measure of the tension between a solid and a fluid.
X Q. 70. Now the oil-water surface tension under the conditions illustrated in your diagram No. 11?
A. I will quote value for oil-water surface tension, 14.
X Q. 71. Would that be dynes?
A. I assume it is. It is not expressly stated.
X Q. 72. Now, the sulphide-water surface tension under the conditions in your diagram 11.
A. As I said a moment ago I know of no measure of the interfacial tension between a solid and a fluid.
X Q. 73. Then we come to diagram 12 and the first item was oil-quartz. That comes under your general statement that there is no measurement?
A I am not acquainted with any measurement of that.
X Q. 74. Now the oil-water, under the conditions of your diagram 12, oil on quartz?
A. The tension of the water-oil interface is not affected by the presence of this insoluble solid.
X Q. 75. So we take 14 dynes, that is what you gave before?
A. That was the value that I quoted from this book.
X Q. 76. And the quartz-water comes under your——
3073 A. That is a solid interface and I do not know.
X Q. 77. Now this oil-water surface tension, is it variable with different oils?
A. Undoubtedly.
X Q. 78. And can you give me any other date than you have given?
A. For oil-water?
X Q. 79. For oil-water.
A. I will quote from Freundlich Kapillarchemie.

Mr. Garrison:

X Q. 80. What does that title mean when translated?
A. Capillary chemistry. It is capillary chemistry or the chemical phenomena connected with capillarity. It is a branch of physical chemistry. Page 128, table 30, title page bearing date of 1909.

Mr. Williams:

X Q. 81. Published by who?
A. Akademische Verlagsgesellschaft, m. b. H. Page 128, Table 30, various substances mentioned here, benzol—I would like to say

that these involve chemical natures of compounds and not being a chemist I am not absolutely sure as to the description.

Mr. Sheridan: Do you want to have Dr. Sadtler or Prof. Bancroft interpret it for you?

Mr. Williams: I will not object.

A. Water and petroleum hydro-carbon; water and benzol; water and turpentine; water and isobutol alcohol; water and iso alynl alcohol; water and ethyl ether; water and chloroform, methyl alcohol and carbon bisulphide.

3074 The Witness (continuing): Or water petroleum hydro-carbon 48. That is undoubtedly dyne per cc. Water-benzol 32.6; water-turpentine oil 12.4; water isobutol alcohol, 1.76; water-isol alynl alcohol 4.42; water-ethyl ether 9.69; water-chloroform 27.7. That is all of that list.

X Q. 82. Now, can you give me the surface tension of an air-water surface?

X Q. 83. Now, can you give me the surface tension of the air water surface?

A. Do you desire me to read from this book?

X Q. 84. Are you reading from the same book you did before? If so, mention it.

A. I am reading from the book, but I must read it in German. I won't be responsible for the translation.

X Q. 85. Well, let Dr. Bancroft read and translate it?

A. Well, I can read it and translate it, but I don't want to be responsible for the translation; I might make a mistake. "The values measured by different methods, pure water at 18°, by different methods"—then there are twelve or twenty different observers. Will it be sufficient if I give the range of values from the highest to the lowest?

X Q. 86. Yes.

A. The lowest there which I find in the table is 71.9—well, there is one 71.7, measured by method called air bubbles. The observer is Sieg and this measurement was made, or rather published

3075 in 1887. The highest value which I see in the table is 76.8; there are two values; one by Timberg, which was published in the Journal de Physique in 1887. The value was measured or determined by the adhesions to a ring made of platinum.

X Q. 87. And these are all at 18° C.?

A. I so understand it to be stated here.

X Q. 88. Now, the oil-air surface tension; can you give me any figures on that?

A. To tell the truth I don't know how many of these oils—but I will read some.

X Q. 89. I suggest that you lend us the book and we will look it over and put in evidence what are necessary so as to save the trouble of putting in the whole list?

A. The book does not belong to me, and I do not feel that I have authority to let it go out of my hands.

The Court: Do you want this to go in as your own evidence or as a part of your cross-examination?

Mr. Williams: As a part of the cross-examination of this witness.

The Court: Suppose you let Dr. Bancroft read it. I suppose you want to use it as part of the cross examination.

Mr. Bancroft: I will be happy to read it for him or to copy out the table for him.

Mr. Williams: Then kindly read the table, and we will get it in the record.

3076 Mr. Bancroft: This is a table of surface tension of organic compounds. First, Hexane: temperature 20°; surface tension 17.4. Kerosene: temperature 50°; surface tension 30. Benzol, temperature 20°; surface tension 28.8. Toluol, temperature 20°; surface tension 28.2. Methylalcohol, temperature 20°; surface tension 23. Ethylalcohol, temperature 20°; surface tension 22. Normal propyl-alcohol, temperature 20°; surface tension 28.6. Isobutyl-alcohol, temperature 20°; surface tension 22.5. Isoamyl-alcohol, temperature 20°; surface tension 23.5. Ethyl-ether, temperature 20°; surface tension 16.5. Glycol, temperature 20°; surface tension 46.1. Glycerine, temperature about 18°; surface tension 65. Acetone, temperature 20°; surface tension 23. Formic acid, temperature 20°; surface tension 37.1. Acetic acid, temperature 20°; surface tension 23.5. Propionic acid, temperature 20°; surface tension 26.2. Normal butyric acid, temperature 20°; surface tension 26.3. Analine, temperature 20°; surface tension 43.8. Pyridine, temperature 20°; surface tension 38. Nitrobenzine, temperature 20°; surface tension 41.8. Chloroform, temperature 20°; surface tension 26. Carbon tetrachloride, temperature 20°; surface tension 25.7. Carbon bisulphite, temperature 20°; surface tension 33.5.

Mr. Williams:

X Q. 90. Those degrees are all Centigrade?

A. All Centigrade degrees.

3077 Examination of Mr. Beach resumed:

X Q. 91. You collaborated, did you not, on the paper entitled "An Explanation of the Flotation Process by Arthur F. Taggart and Frederick E. Beach," portions of which I read to Professor Taggart during his testimony?

A. No, sir, not in that paper.

X Q. 92. Was it written entirely by Professor Taggart?

A. We did not write that paper.

Mr. Sheridan: I don't think Mr. Williams should ask that question, so I object to the form of the question. How should Professor Beach know anything about it, if Professor Taggart wrote it entirely.

The Court: The form of the question is all right, but it calls for hearsay.

Mr. Williams: He might have seen him write it.

The Witness: If the court please, I would like to state that we did not publish in that journal, and I never to my knowledge read that matter which he presented to the court. It is not our paper at all.

A. If the court please, I would like to state that we did not publish in that journal—I never to my knowledge read that matter that he presented to the court. It is not our paper at all.

X Q. 93. That is to say, this publication which appears in the Metallurgical and Chemical Engineering. Have you read it?

3078 A. The Journal that you have quoted did us the honor to reprint the paper. It was not by any authorization of my own. I hadn't the opportunity to correct the proof; I don't remember that I ever read the text that you quoted in the court yesterday.

X Q. 94. I show you a document entitled "Transactions of the American Institute of Mining Engineers" and a paper having the same heading. Will you accept that as authentic?

A. That is our paper, yes, sir.

Mr. Williams: I will have that identified paper marked for identification.

(The paper entitled "Transactions of the American Institute of Mining Engineers" marked Plaintiff's exhibit 138 for identification.)

Mr. Williams:

X Q. 95. I read from the authentic publication: "The importance of flotation lies in the fact that it is primarily a 'slimes process' by means of which the particles of valuable mineral, too fine for efficient gravity concentration, are saved with a high percentage of recovery. Recoveries in the mills treating low grade copper-sulphide ores have been advanced twenty per cent by the installation of the process and similar increased savings can be accomplished by the same means in mills treating sulphide ores of zinc and lead." You accept that statement as authentic from yourself and Professor Taggart?

A. I have not qualified to testify in regard to mill operations.

3079 X Q. 96. That is to say you are a physicist and not a metallurgist and you want to draw the line; is that the idea?

A. I do not feel that I can offer testimony upon that technical subject which would have any weight. I am not qualified as a mill expert or a metallurgist.

X Q. 97. Were you present when I read these extracts to Professor Taggart?

A. I was.

X Q. 98. Can we save the time by my asking you whether you accept those parts that I read to him?

A. I did not have the copy of the paper present and I do not know that it was an authentic copy.

X Q. 99. I read from the authentic copy as follows: "The conclusion——

The Witness: Excuse me; would you indicate the page upon which that appears?

Mr. Williams: Page 1376.

The Witness: And what portion?

Mr. Williams: Commencing about the middle, under the pictures. "The conclusions forced by observing the above phenomena are:

"(1) That water has a smaller tendency to displace air on the surface of sulphide minerals than on the surface of gangue minerals.

"(2) That the tendency of oil to displace air is greater at the surface of sulphide minerals than at the surface of gangue minerals.

"(3) That oil tends to displace water on the surface of sul-
3080 phide and that water tends to displace oil at the surface of gangue mineral.

"(4) That water displaces air more readily on an oiled solid surface than on a clean surface of the same solid.

"(5) That these tendencies toward displacement are due to the interfacial tensions or pressure existing between the various substances, and that the resulting action of this interfacial force is a manifestation of the tendency toward reduction of the total potential energy of the system. Whenever an increase in the solid-fluid interface will decrease the potential energy, such a change will occur." Do you accept that as accurate and as representing your views today?

A. No, sir.

X Q. 100. Is it accurate—is it an accurate statement of what was published in this authentic paper of yours?

A. Well, I desire to say—I do not understand that I have testified to the contents of this paper. This paper is not a part of my testimony in this court. It was not made under oath. It was done in collaboration with my colleague and was done honestly at the time and represented our views honestly at the time, but I desire to say that I am not prepared to introduce it as my testimony and my language in this court.

The Court: Well, the object is, you are here as an expert in reference to special matters in this case and they have a right to ask you about other statements that you have made, not that you have sworn to them, necessarily, and to see if your views have changed,
3081 also.

The Witness: I would desire to state, the physical facts involved there are not stated in the language which I should use. When two men work together in collaboration they do not always look at the facts from exactly the same angle and they frequently have a difference of opinion as to how particular phenomena should be interpreted and they usually—often there are some compromises between the different points of view. This statement here represents, I think, an average of the views of the two authors of this paper. I should be very glad to state my own views in regard to the phenomena which are involved there, but I would, if the court please, rather not say that these are my words because I do not know that they were used by me.

The Court: If they are not, of course you will just state what the

facts are, as you remember them. It is not an attempt to try to bind you, Mr. Beach, to any particular view, but that we may have a full understanding of how this was written, and you have stated how it was prepared. You have stated how it was written, and you have a right to explain or modify what you now consider to be the truth of the matter.

Mr. Williams:

X Q. 101. I will say that I haven't the slightest desire to trap you into any statement you will not accept, and my purpose in asking you is to know whether you would accept it. Now, if you will explain your views—if you wish to explain your views otherwise as to these phenomena you will kindly do so.

3082 A. The paragraph numbered one, I should say, expressing my views in regard to the phenomenon which I suppose is the real point or crux of the question, that water will displace air more readily from the surface of the gangue minerals than from surfaces of sulphide minerals.

Mr. Williams:

X Q. 102. Which is the antithesis of this statement, is it not?

A. It is not, no.

X Q. 103. All right, I will withdraw that then. All right, go ahead.

A. I think that my statement amounts to the same as is made here, but I would prefer to change the language if I were to offer my testimony in regard to this fact. In regard to the next number?

X Q. 104. Go right ahead.

A. Oil will displace air more readily at the surface of sulphide minerals than at the surface of gangue minerals.

No. 3, oil displaces water more readily on the surface of sulphide than on the surface of gangue minerals. Water displaces oil more readily at the surface of gangue minerals than at the surface of sulphide minerals.

(4) Water spreads more readily on an oiled solid surface than upon a surface uncontaminated with oil.

(5) These displacements can be expressed in terms of the interfacial tensions or energies and the resulting action of these interfacial forces will diminish the potential energy of the system.

3083 If a change in the area of the solid-fluid interface will decrease the potential energy, such change will automatically occur when the system is freed from constraint. I think, Mr. Williams, that states in my own language the substance of these paragraphs and I desire to say that I do not believe that the sense or meaning of them has in any point been essentially changed.

X Q. 105. Following what I read and what is expressed in your own language, the paper says: "These conclusions suggested the following confirmatory experiment," and then there is a description and an illustration of an experiment wherein an aluminum ring was cleaned and floated on the surface of pure water, and then the

ring was oiled slightly, and it was found that the water came over the surface and that it was impossible to float the ring. You accept that experiment as an accurate experiment, do you not?

A. I do. I would like to enlarge upon that statement a little.

X Q. 106. Go ahead.

A. I hold in my hand the aluminum ring in question. This ring was floated on clean water. (Drawing diagram.) I have not all the figures in my note book; I think the statement of the dimensions of the ring and the density as given in the paper are correct. This ring was cleaned by washing it with a cake of Sapolio, or Bon Ami; it was washed with soap, thoroughly rinsed, and taken up in clean filter paper so that it did not come in contact with
3084 the fingers. A small wire carrier with three projecting prongs was used to hold it and drop it down upon the surface of the water. The ring then floated under the influence of the forces of surface tension, which were applied at lines of contact, running around this outer portion of the ring, and the inner portion of the ring.

Mr. Sheridan:

Q. 107. Do I understand that those are two rings, or is it a cross section?

A. This is a cross section of this particular ring, the dimensions being given in the paper.

X Q. 108. The ring lies horizontal upon the surface of the water?

A. The ring lies horizontal upon the surface of the water. I then attached to this ring some fine copper wires, three of them, I think, making a little basket or pan in which I could put shot, endeavoring to find out how much load in addition to its own weight this ring would support under the influence of these forces of surface tension "T."

Mr. Williams:

X Q. 109. You might mark "basket" at the bottom.

A. I have marked it "basket and shot." I did not expect that this would be called for at this time, therefore I have not provided myself with the data. I will quote from memory, which is to the best of my knowledge and belief. The total added weight which it was possible to put on there was something like 1.7 gms.; I am sure it was over 1 gm., but I am not quite sure whether it was one
3085 and six-tenths or one and seven-tenths—a variation of one-tenth. The ring was then removed from the water, thoroughly dried, and taken in the fingers; a bottle containing oleic acid was shaken up and the cork was removed, and I rubbed my fingers on the cork so that they were slightly oiled. I then passed the ring through my fingers and rubbed on a little of oleic acid, not enough so I could see it, but so the surface, I believe was coated with a thin film of oleic acid. I then replaced, or attempted to replace this ring as carefully as possible upon the surface of the water, but I found, with whatever care I exercised, it was impossible to float the ring

alone. I then tried it with two different oils; the bottles which I used were labeled "crude oil" and "creosote." They had been furnished by Professor Taggart from a number of specimens, and I know nothing about the history of the oil. I presume he could state it if there was any question. I then found that with the crude oil the ring acted as though it was going to float, but did not; it just wavered at the surface and then sank. There was evidently a difference between the oleic acid and the crude oil in the matter of flotation. With the oleic acid it went down much more promptly. I then tried another oil which was called creosote on the label on the bottle. I found when I had oiled this way I indicated, simply by rubbing it with slightly moistened fingers, that the ring floated—I am still quoting from memory—for a space of seven minutes while it was under observation. I left it in my room when
3086 I went to lunch, and when I returned I found it was at the bottom of the jar. Whether the janitor had been in the room and it had been disturbed, I do not know. I do know this, that it at least floated for seven minutes. There was a difference in those effects. Now, this I regard as a confirmation of the statements that I have made, in this way: I took this piece of aluminum, which I cleaned off very carefully, rubbing the surface with an abrasive soap, and then some plain soap, like Ivory soap, and washed the ring carefully in water and dried it with filter paper and was careful not to touch it at all, and then from a medicine dropper I put upon that surface a drop of water, and I determined what I called this morning the angle of repose.

(Drawing another diagram.)

I found that the angle, as I stated this morning, was approximately 85°; it varied a little—a degree or a degree and a half either side of that. I then took this surface of aluminum and touched it with the moistened cork of the bottle, and rubbed my finger over it, and put a drop of water on there as before. When I used oleic acid I found the drop had that shape, and that its angle of repose was about 39½°. I tried the other oils. The crude oil—this little wavy line represents contaminated surface. With the crude oil I found 65° and with the creosote I found 69°. These measurements were made after the experiment had been completed.

Now, I would like to refer to my first diagram.

3087 Mr. Sheridan: You better mark that diagram No. 15, so you can identify it.

The Witness: Referring to my diagram No. 15, the angle between the tangent to the liquid surface and the tangent to the cylindrical surface of the clean water and clean aluminum was a relatively large angle; that angle in the other cases had been diminished; in the case of the oleic acid the angle was between 39° and 40°. The forces of surface tension in the liquid surface being very nearly horizontal, it had a small vertical component. As this angle was small, there was very little spreading effect.

X Q. 110. Mark the angle that you say was small?

A. It is this angle here.

A. The angle was smallest in the case of the use of oleic acid. In that case I was not able to support it at all. When the angle had been increased, in the case of crude oil, to 65°, it seemed to be just on the point of being supported, the force had been more nearly the original position of the pure water. When the angle increased a little larger to about 69° as I measured it, I found that it was possible to support the weight of the ring alone for at least seven minutes—I don't know how much longer—and when the angle had been increased as shown here to 85° the vertical component of the force being very much larger, it was possible to support not only the ring but an added weight of something over one gram.

3088 X Q. 111. Now, will you kindly mark the other diagram, Diagram 15, and I will offer it in evidence.

The diagram was admitted in evidence and marked Plaintiff's Exhibit 139.

Mr. Williams: I will now offer diagram 16.

Said diagram admitted in evidence and marked Plaintiff's Exhibit 140.

Mr. Sheridan: Professor Taggart made two diagrams on the blackboard that are marked Taggart's diagrams No. 1 and No. 2, which we will offer in evidence as defendant's exhibits 141 and 142.

Said diagrams were admitted in evidence without objection and marked Defendant's Exhibits 141 and 142.

Mr. Williams:

X Q. 112. Relative to the statement on page 1385 of the authentic paper in regard to the pneumatic froth process, "sulphide and gangue minerals mixed with water and oil, with or without acid, are run into a tank with a porous bottom through which air is forced. The air bubbles rise to the surface with a coating of solid particles preponderately sulphide, while the gangue particles sink.

"The principles involved in this method are the same as explained in the agitation froth process. The only difference is in the method of introducing air. The result of this difference is that the

3089 bubbles in the pulp are much larger than in the agitation froth method; they arrive at the surface less heavily laden in proportion to their area; the bubble films are, therefore, less viscous and the froth less permanent."

First I will ask you if I have correctly read from this paper.

A. I believe so.

X Q. 113. Now, as to these statements, do you accept them as proper statements today?

A. These represent the result of my own observation.

X Q. 114. On page 1384 I read, "Case 2, Sulphide, Gangue, Water, Oil and Acid—The addition of acid has the two-fold effect of further lowering the surface tension and increasing the adhesion ratio." Have I read correctly from the paper in question?

A. You have not read the adhesion ratio.
oil-solid.

X Q. 115. The adhesion ratio is water-solid. I thought perhaps it would be just as clear to the several courts who will have to consider this matter with the statement of this ratio omitted. Is that correct now?

A. It is a correct reading of the passage.

X Q. 116. Now, what have you to say as to that statement?

A. These are the views which we held at the time the paper was written, from observations which we had made. Today I am still of the opinion that the effect of acid is to bring the water into
3090 more intimate contact with the gangue mineral, that is, the adhesion of acidulated water to gangue as indicated by the angle of repose, is apparently a little greater than for pure water in the gangue. I understand you are asking me about the effect of sulphuric acid?

X Q. 117. Yes.

A. I am trying to answer that question. Today I am of the opinion that the presence of sulphuire acid assists in flocculation or precipitation of the gangue, although I do not offer this as an expert opinion, as I am not a chemist and this belongs rather to the realm of physical chemistry than to physics. In regard to the other statement as to the effect of acid upon the surface tension of the water, I have found various statements of various authorities, some saying that it lowers it and some saying that it raises it. The best information that I am able to obtain at the present moment indicates that the presence of sulphuric acid slightly raises the surface tension of water, but only very slightly up to a 10% solution of the acid in water. Have I answered the question?

The Witness: Mr. Williams, may I supplement that statement with one reference?

X Q. 119. Certainly.

A. I would like to call your attention to Figure 14*c*, page 74, of Freundlich Kapillar Chemie in which the course of the curve, indicating the effect of sulphuire acid on water, is given. The ordinates being the numerical value of the surface tension and the abscissae, percentage of water and acid.

3091 X Q. 120. And what, in general, does this table show?

A. That with pure water the tension is a little over 75 dynes and as the quantity of sulphuric acid is raised say, to about 8% which is the first point on the curve, the rise is practically horizontal, indicates no very sensible apparent change. After that, up to about 50% solution, the surface tension is raised to a value a trifle over 79, and after that the higher the concentration of acid, the surface tension seems to fall.

X Q. 121. So that the more concentrated acid has the lowest surface tension; is that right?

A. That is as I understand the diagram which he has given here. I have not studied this diagram, it has only recently been called to my

attention, but I mentioned that to indicate that the rise with small quantities of acid is almost negligible.

Mr. Williams: I think I would like to offer in evidence a copy of this diagram and I will have the copy made. (Page 74, Figure 14c.)

The diagram was admitted in evidence without objection and marked Plaintiff's Exhibit 143.

The Witness: May I supplement my statement with a still further remark? That variation of surface tension indicated in this diagram with a concentrate of sulphuric acid is far smaller than the variation between the different measured values which we
3092 have already quoted for water carrying from 71.7, lowest value, to 76.8, the highest value. The variation there is over 6% between the different determinations of surface tenison of water.

X Q. 122. Is there a selective action of the air in water as between metal and gangue?

A. I don't think I understand your question. I don't understand how air can be in water.

X Q. 123. Well, you may have a bubble of air in water. That is, I take it, the easiest way to put air in water.

A. Well, please restate the question, introducing the bubble.

X Q. 124. Is there a selective action of bubbles of air in water as between metallic sulphide and gangue?

Mr. Sheridan: I would like to have the counsel state whether he means pure, uncontaminated water, because water varies in various sections of the country.

The Court: This gentleman is an expert on this question. In his answer he may qualify it or illustrate it or draw the distinction.

A. The condition which you have stated is a rather complex one and I do not feel that I can answer it unless I were to represent to my eye the conditions that you have in mind as to how the bubble is placed with respect to the material. I don't fully grasp the ...nt of the question. I may say this, that as far as I do underst..nd the question, that air is differently adsorbed at different ..rfaces.
3093 If you have a piece of sulphide in air, there will be a different adsorption of air possibly on the sulphide from what there will be on the quartz. Now, if that is introduced into water the water may displace one of these adsorbed layers more readily from one surface than from the other. But what condition of thing you contemplate as to the position of the bubble of air with respect to the sulphide I do not quite understand.

X Q. 125. Assume a particle of sulphide immersed in water resting upon the bottom. Assume a bubble of air presented to the bare surface of this sulphide particle by being pushed down to it. What will happen when you, after making a good contact between the bubble and the metal, permit the bubble to rise?

A. May I answer that by a diagram?

X Q. 126. Certainly.

A. (The witness draws a diagram.) Have I correctly apprehended the circumstances you have in mind?

X Q. 127. Yes, your sketch represents the condition, and here is a bubble attached to a bubble holder. The bubble of air is brought down and touched to the clean sulphide.

A. Under these circumstances I am of the opinion that this angle of repose, as I have called it, would be essentially the same as the angle that would be made by a drop against the sulphide surface. That is, the angle between the air-water surface and the sulphide-water surface. This is the angle here between the air-water surface and the sulphide water surface.

3094 X Q. 128. Now, what would happen if the bubble holder were lifted upwards?

A. The force of surface tension has a certain component. If the particle of sulphide were greater than the total value of the upward pull of surface tension it would not be lifted from the bottom but the bubble would stretch out and would finally neck off, and we should have a complete spherical bubble attached to the bubble holder and probably a little watch-glass bubble attached to the surface, in case the sulphide was too heavy. If the sulphide particle was not, then I should expect that the bubble would lift to the surface through the water.

X Q. 129. And if the weight of the sulphide particle as immersed in water was less than the buoyancy of the air bubble, the air bubble would lift the metallic particle; is that correct?

A. I think it might. I wish to correct my former statement about what would happen to this bubble. There is another possibility: If the sulphide were too heavy and the bubble holder were lifted this bubble would stretch out in a cylindrical form. The diameter here would become less and it is just possible that the water would creep in from each side until it was detached. That is another possibility. I have not tried the experiment and I can not swear from observation.

X Q. 130. Now, the purpose of my inquiry was to bring about some explanation as to the selective action of air bubbles.

3095 Now, what would happen if there was a substitution of gangue for clean sulphide, clean gangue; other conditions remaining the same?

A. A drop of water put upon clean gangue makes a very small flat shape; it spreads out; the angle of contact is very small, and I apprehend that this angle there would be the same as the angle of the tangent there, and there would be a slighter attachment of the air to the gangue than with the sulphide.

X Q. 131. In consequence of that you would expect that the bubble, by its buoyancy would exercise very little lifting power upon the gangue particle?

A. I would, provided, of course, always that these surfaces are not contaminated with oil. This is a clean sulphide, no oil present, and clean gangue, no oil present. Would you like me to tell what happens when there is oil there?

X Q. 132. Yes, suppose you tell us what would happen with oil.

A. I will have to draw another diagram——

(Last diagram marked "Beach diagram No. 17.")

Mr. Sheridan: I offer diagram No. 17 in evidence.

Diagram admitted in evidence without objection and marked Defendant's Exhibit No. 144.

The Witness: Let this represent the surface of sulphide, oiled. Suppose that I moisten my finger slightly with oil and rub it
3096 over the surface, and I put upon that surface a drop of water. The drop of water, instead of standing up in a large heap, will flatten out so as to make a much smaller angle than that shown in the preceding figure. With the bubble holder the attachment of the air to the sulphide surface will now make a small angle. I have a note book full of measurements, made upon that. It is far less than upon clean sulphide. The clean sulphide is somewhere from 80° or 90° minimum, and when I use oil it sinks down to 25° or 30°, and we have here a condition such as if—such that if you begin to lift on that, this part here will run over those oil surfaces; its interfacial surface having been diminished, and the particle will not be raised. I would like to state that I tried out that theory thoroughly, and found that it was insufficient. The moment that I saw a flotation machine in operation I rejected the idea that the particles of sulphide were lifted by the minute bubbles attached to the particles.

X Q. 133. I will ask you to sketch on that sheet this: suppose that you have sulphide mineral, clean, and water containing soluble frothing agent dissolved in it, what will be the condition?

A. (Drawing.) I am representing there a drop of this water with the contaminant, the same as with the pure water.

X Q. 134. Are you assuming any particular contaminant?

A. I understood you to say a soluble contaminant.

X Q. 135. A soluble frothing agent. Take acetic acid, for instance?

3097 A. Do you object to the use of the word "contaminant"?

X Q. 136. Well, it must be a frothing agent?

A. I don't know what you mean by a frothing agent.

X Q. 137. Phenol, creosol, acetic acid, amyl acetate, whiskey, valerianic acid—there is a long list of them?

A. I think we could find experimentally what would happen by using a drop of this water with a frothing agent, putting it on the clean sulphide surface and observing that angle. The substances which you have named I have not personally tried. I believe that most of those, as I remember you naming them over, have the effect of reducing the surface tension.

X Q. 138. That is right.

A. It is my opinion that the effect of these contaminants or soluble frothing agents is to reduce that interfacial tension, and to allow the drop to spread out flat. It can be tried. I have not personally tried it in the case of these substances. I have tried it with sulphuric acid, and in our experiments with sulphuric acid I found the increase here—I am quoting from memory, but to the best of my recollection and belief—I cannot say that there were any exceptions—I will say

this, in the majority of cases I found that the angle of repose was less than in the case of pure water, and therefore when we come to the question of the bubble attachment to the bubble holder—I am now giving my opinion—my opinion is that this angle would
3098 be smaller than in the case of pure water against a sulphide, and that the lifting power of this bubble would be diminished.

(Whereupon a short recess was taken.)

Beach diagram No. 18 admitted in evidence and marked Defendant's Exhibit 145.

X Q. 139. Now, I would like your explanation, professor, of one other set of conditions. Instead of water, oiled sulphide mineral at the bottom, take the air bubble presented to the sulphide mineral in oil?

A. What are the conditions?

X Q. 140. Oil; a body of oil, and a bubble lowered in the bubble holder and presented to the sulphide surface as before?

A. I should say that I have not seen or studied this condition, but as a method of investigation it is perfectly general. I should proceed by placing a drop of oil upon the sulphide surface.

X Q. 141. Which you have done, of course?

A. I have done that, and I know that the angle is small. I have measured a lot of angles, but I have not them with my notes here. The angle of contact between the water-oil surface, and the sulphide surface will be essentially the same here as it was there, and I should expect a very slight attachment of the bubble to the sulphide.

X Q. 142. You said water; you meant air?

A. Air. Of the air bubbles to the sulphide surface.

3099 X Q. 143. And the consequences of that small angle would be what as to the lifting power of the bubble?

A. The air-sulphide interface has a larger amount of surface energy than the oil-sulphide interface. The tendency is for this oil-sulphide area to increase, and the air-sulphide to decrease. Therefore, I should expect, under the disturbance of the original condition, trying to lift it, that the oil would come in from the side, and the bubble would detach itself without causing any sensible lifting power to the sulphide. All these answers have reference to particles of sulphide or quartz that are large compared to the thickness of the adsorbed layer of interface; I was not discussing finely ground ore in any of these cases.

(Diagram last referred to marked Beach diagram No. 19.)

Diagram admitted in evidence without objection and marked Defendant's Exhibit No. 146.

X Q. 144. Now, let us assume all the conditions as in diagram No. 19, except that we have finely powdered sulphide on the bottom of your glass or other vessel filled with oil, and an air bubble carried down by the bubble holder and brought into contact with these very fine particles. What then would happen?

A. I would like to draw a diagram of that to make myself perfectly definite. I understand this was to be in oil?

3100 X Q. 145. Yes.

A. This drawing represents the presentation of an air filled cavity in a pool of oil to some sulphide particles which are resting on the bottom of the containing glass vessel. This interface between the air and the oil is undoubtedly the seat of a certain amount of adsorption of air. I have no experimental evidence which would indicate that in the absence of water a sulphide particle has any different potential energy in that air-water interface from what it has in oil. I should expect that some of the sulphide particles might be held up by film flotation on the lower part of the bubble, but I have no experimental data which would enable me to predict, although I think it highly probable that if such a bubble were presented, that the surface energy—the surface tension of this layer is a little different, probably a little less than what it is in the bubble, and I should expect to find some of those particles entangled in that layer, especially as their presence there would increase the viscosity, and if they once touched the interface they would not be readily drawn up from it.

X Q. 146. That would depend upon the relationship of the oil-air surface at the inside of the bubble, and at the metal oil surface of the immersed particle, is that not correct?

A. It would depend upon the general adhesive relations of those particular substances, which I have not personally studied. I may say that in general when a particle of a substance gets into an interface, or a number of them get there, they increase the viscosity,

3101 and it is a little harder to pull them out after they have once been in there; under the influence of the weight of the oil they may get tangled in that viscous interface, and they are not easily removed and shaken off, and I think perhaps the same thing would happen in an air-oil interface in the case you have asked about.

X Q. 147. You last referred to your test No. 12?

A. Test No. 12, yes.

(Last diagram marked "Beach diagram No. 20).

Diagram admitted in evidence without objection and marked Defendant's Exhibit No. 147.

X Q. 148. Is there any difference between adhesiveness and adsorption, or in what manner are they related?

A. By adhesion I understand the molecular attraction of the molecule of one substance for the molecule of another substance. They stick together, if we discuss it in terms of forces, but in general I prefer to discuss the thing in terms of energy. The result of the molecular attraction between the molecule of sulphide and the molecule of oil is to concentrate a layer of the substance at the interface, and that layer of transition where the concentration takes place, is called the adsorption layer, and the change in concentration is known as adsorption.

X Q. 149. Can you give me any dimensions as to the
3102 thickness of the interface where we have a bubble of air immersed in water and containing what you have described as an inner oil layer, I believe?

A. I don't remember using the term, inner oil layer, but to reply to the question as to thickness, I have not any very definite idea; it varies, undoubtedly, with the substance in service.

X Q. 150. Take, for example, the interface between oil and water of which you have spoken to a considerable extent. Can you give any definite dimensions as to the thickness of that interface?

A. I cannot. It would undoubtedly vary with different oils, and especially with the different solids that happened to be present. In the case of the kerosene and the inky water, that film—I don't call it an interface—but that adsorption film, I should judge, was smaller than in the case where it was loaded up with metallic particles as in that bottle to which you just referred.

X Q. 151. Now, let us take the simple case of kerosene oil in contact with water and no metallic particles?

A. Yes.

X Q. 152. Can you give a definite statement as to the thickness of that interface?

A. I suppose that it is more than one molecule thick. Whether it is more than 100 molecules thick, I do not know. I am not aware that any experimental investigation or estimation of that thickness has been made.

3103 X Q. 153. Now, let us assume an oil-air surface with no metal present. What would be the thickness of the interface?

A. I don't understand that an interface has any thickness. The adsorbed layer has a thickness. I am not aware that any measurement has been made of the thickness of the adsorbed layer or if it has these things are not known to me. They belong to the realm of physical chemistry and that is not my specialty.

X Q. 154. Well, can you give us any idea of the thickness represented by what you state as the possible maximum in the case of oil and water, 100 molecules?

A. I can't, expressed in centimeters or inches.

X Q. 155. It is so impossible for the lay mind to think in molecules that I was trying to find out if you, as a physicist might not help us to get a picture of what was described. Can you do so?

A. Well, the picture in my mind is that we have a layer of molecules in the case of the water-kerosene surface—I suppose that some of the water molecules are dispersed or diffused into the kerosene and some of the kerosene molecules are mixed or diffused into the water. In physics, we do not regard absolute discontinuity, and accordingly things shade off gradually, these things are more or less mixed or intermingled at the interface. As to the thickness of it I have no conception.

X Q. 156. Now, in case of an adsorption layer of an air bubble immersed in water, can you give a picture of the minimum

3104 condition wherein that adsorption layer is one such as you have described, containing oil and shading off into the water?

A. I am not quite sure that I apprehend your question. It is the boundary between water and air, the air being within a cavity and the water surrounding that?

X Q. 157. And there being an oil adsorption layer at the interface of the air bubble. In other words, the condition that you found when you have oil present in water and air bubbles in the water—and these air bubbles have met some of the oil?

A. I think, Prof. Taggart drew a diagram yesterday and I will refer to his drawing. If I have correctly apprehended the question, referring to diagram 7 of Prof. Taggart, Defendant's Exhibit, 130, referring to the portion of the diagram lettered A, which I understand to represent a face containing air and this to be an oil contaminated surface, and this to be——

X Q. 158. (Interrupting.) And outside of it, water.

A. Water, possibly containing oil or not, as the case may be, but mostly water. I understand that there is a greater concentration of particles of the oil at the interface, that is, where the air begins, because thereby the oil lowers the surface tension or reduces the potential energy of the system and those particles of oil depending upon its degree of solubility, will shade off very rapidly if it is an insoluble oil, so called, and much more gradually if it is a soluble oil. There is also undoubtedly more or less compression or concentration of the air molecules near that surface. If there is a

3105 sufficient amount of oil present then we may have a pure oil at this surface just as in the case where we put a drop of kerosene on a glass of water and the kerosene spreads over almost indefinitely and makes a layer so thin or so minute that it can only be perceived by special tests. Have I apprehended your question, or answered it?

X Q. 159. Yes. If we assume what are generally called insoluble oils, can you give any explanation of the minimum condition when there would be a substantial concentration at the interface, that quick shading off that you speak of?

A. The minimum condition, I judge, would be a layer of molecules, one molecule thick. That is the least that I can conceive of.

X Q. 160. And it is conceivable that there may be such a condition?

A. I think so.

X Q. 161. That is to say, there is no reason why, under the forces that are at work there, you would not be able to spread out on the interwall of the bubble, a layer of oil one molecule thick?

A. I am not sure that I understand the question, but as I understand it, the least amount of oil which would produce a contaminated surface there having the same properties all over, would be a layer one molecule thick. If we had less than one molecule thick they would be more or less bunched together in some places and scattered out in others and the surface would not have the same properties all over.

3106 X Q. 162. Now would such a layer, one molecule thick, be of utility in the concentration of ores?

A. I should not suppose it would for the reason that the particles which are being lifted are of a size very large compared with the dimensions of a molecule.

X Q. 163. What further additional thickness would alter the condition of the problem?

A. I don't quite know what you mean by "the condition of the problem." Do you mean how thick a layer would be operative?

X Q. 164. I understood that you said something about the surface energies being unaffected by thickness after a certain minimum thickness had been attained, and I would like to get that minimum thickness that you had in mind.

A. That is not my understanding of the statement. My statement was this: That the surface tension of a liquid film, that is, with an upper and a lower surface, a liquid film does not depend on the thickness as long as that thickness exceeds a certain small value: Do you want that thickness?

X Q. 165. Yes.

A. I can only quote that from memory as I haven't my notes with me. I have represented here (drawing a diagram on paper); a molecule of any substance and here is another molecule of the same substance. Then, the limit of molecular range, I mean the greatest distance which we can separate these molecules and still have this one act upon that, that distance, d, is, I believe, 1/20,000
3107 mm. Liquid films, soap films have been measured which are considerably thinner than that. By "considerably" half or a quarter. The soap film ceases to show the ordinary colors and becomes dark. That is called the black spot. The thickness of the black spot, I believe, is quite a little less than that. The number I cannot recall at the moment, but if it is thinned out beyond that thickness that film changes its properties in rather an erratic way, and if it is much thinner than that undoubtedly it breaks, but I am unable to quote from memory and I have not sufficient data here to specify that.

obtained in the agitation froth flotation process?

A. As to the minimum film?

X Q. 167. Yes.

A. No.

X Q. 168. You have no measurements?

A. I have no measurements of their thickness. When they are loaded with these metallic particles as in the flotation process they undoubtedly have a thickness which is not of ultra-microscopic character, but a sensible fraction of a millimeter. I mean the whole thing, including the mineral particles which are imbedded in it.

X Q. 169. There must be, I take it, a sensible difference in the thickness of the adsorption layer around an air bubble when it emerges from a liquid as contrasted with the adsorption layer
3108 when it is immersed in the liquid? Is that true?

A. It has a single adsorption layer when it is in the liquid and when it emerges it has a double adsorption layer, one inside and

one outside, the thickness of that film being dependent on the metallic load which it carries. And it would——

X Q. 170. And it would have a definite relation to the thickness of the adsorbed layer of the immersed bubble?

A. I don't think so.

X Q. 171. Would it be thicker of necessity?

A. Because there are two adsorption layers, I should think it would.

X Q. 172. Can you give me any definite idea of the thickness of the adsorption layer of contaminated immersed air bubbles in the absence of solid particles in the bubbles?

A. Such information is not within my memory. It is possible that the physical chemists have made such measurements but I can not supply them at the present moment.

X Q. 173. And as to the thickness of the double adsorption layer or film of the bubble, that has emerged from the water, can you give me anything definite as to that?

A. Why, it may be something in my judgment a quarter as large as that that I have written on the blackboard and it may be anything above that. I do not know that there is any special limit. In
the kind of phenomena which we had in this experiment
3109 No. 7, the thickness of these colored water globules could be
anything. The interface there was air, in that particular case, was an air water interface; and the outer surface in that case was an oil-water interface, and the thickness between them as we observed it, might be anything over a millimeter.

X Q. 174. I would like a definite statement from you as to whether or not the affinity of air for metal is utilized in the froth flotation concentration of ore.

A. In the agitation froth process, or in the pneumatic froth process, it is not. It is not, except in as far as there may be air adsorption in this interface.

X Q. 175. That is, there may be air adsorbed at the oil-adsorption interface?

A. There may be air adsorbed at any place where air is in contact with another liquid or another solid, but in my judgment, air plays a relatively insignificant part.

X Q. 176. Now, it is true, is it not, that where you employ oil in the concentration of ores, varied in the procedure of agitation froth flotation or pneumatic froth flotation, that there is an amount of oil so small that you get no practical results at all from it? That is true, isn't it?

A. If I understand the question, no. Will you please repeat it?

(Question read.)

A. Now, I understand if there is any oil present at all that
3110 it has some influence in forming these contamination layers
and it acts in the process.

X Q. 177. Well, it is a fact, is it not, that you can use too little oil to get any practical result at all?

A. It is all a question of degree, a question of the stability of the

film that you get. The actual operation of the mills or the cells, I am not competent to discuss. I would give it as my opinion that the difference between a minute quantity of oil and a large quantity of oil is wholly a question of degree and not a question of difference in kind.

X Q. 178. Well, now, I am assuming something more minute than the minute quantity of oil. Conceding that, you can get no practical results at all; isn't that so?

A. I don't understand what you mean "assuming something more minute than a minute quantity." Would you put that in figures?

X Q. 179. I understood when you said "minute quantity of oil" you referred to the minimum quantity of oil that was used and produced useful results. Now, I say if you go down below that you impair your results, do you not?

A. That is a question of technical operation of which I have no adequate knowledge.

X Q. 180. Now, let us assume that you had one drop of oil to ten tons of water, and suppose you undertook to impregnate that water with little air bubbles by sending the bubbles up through a porous bottom. What would you expect to be the result of that one
3111 drop of oil in that ten tons of water upon the millions and millions of air bubbles that would be distributed through the mass?

A. I would expect that this oil would adsorb in the air-water surface of some of the bubbles which it first met. It might distribute itself in one bubble or it might distribute itself in a thousand bubbles; and if any one of these bubbles came in contact with a sulphide particle, it might pick up one sulphide particle. Whether that is a commercial operation or not I am not qualified to say.

X Q. 181. Now, let us start with an ore pulp, and in that ore pulp we have a drop of oil, and ten tons of ore and twenty tons of water, and we agitate that very vigorously, and then we pass it into spitzkastens. We use every possible effort to thoroughly disseminate that oil through the pulp and bring it in contact with metallic particles; what would you expect to happen under those conditions?

A. If I had apparatus sufficiently delicate I should expect to find some air-water surfaces and possibly bubbles which were contaminated with the oil, and possibly a particle or two of sulphide imbedded in it; but it is a needle lost in a haystack.

X Q. 182. Now, isn't it conceivable that there is some point at which—some point in the oil quantity or degree of oil quantity at which, when added to that pulp, we bring about the concentration in a froth of the maximum number of sulphide particles?

3112 A. No, not a maximum. If the first condition raised one sulphide particle, and you doubled it, you might get two; if you trebled it you might get three. The thing would appeal to me as a matter of degree. I know of absolutely no dividing line, no critical point of change.

X Q. 183. But isn't it true that you have got a certain number of sulphide particles in your pulp; you have a certain definite number of sulphide particles in your pulp?

A. Yes.

X Q. 184. I am assuming all other conditions equal, and I am merely adding oil enough to get, say, ninety per cent of the sulphide particles in that pulp to the surface in the form of froth. Isn't it conceivable that there is a certain quantity of oil that will do that?

A. A certain quantity—depending on what is sufficient to do it?

X Q. 185. Yes.

A. I suppose it is, but I also suppose that if you attach a little more oil, it will do it just as well or a little better.

X Q. 186. Now, I am assuming that keeping the conditions equal you have found out just how much oil will do it. Now, do you say that having added a little more oil it will do it better—I can't understand that? After a thing is done it is done. If you will explain, I will try to understand it?

A. Well, by doing it better I mean hold them more securely, make a more stable froth, less likely to escape from it, bring it up
3113 more readily; it may take longer agitation with a minute quantity of oil than with a larger quantity of oil.

X Q. 187. Then you think the addition of oil will make for the stability of the froth—the addition of the oil beyond what is necessary to bring them up will make for the stability of the froth, is that correct?

A. As I understand the conditions which are proposed, if we had a film which contained a very sparse layer of metallic particles, the viscosity would be relatively small. If we use more oil, that oil would adsorb upon those particles and more of them would stick to it, and the resulting bubble film would be more stable and more persistent.

X Q. 188. Then there would be a certain oil proportion by the use of which you would get a certain best condition of stability?

A. I don't know what you mean by best condition.

X Q. 189. Suppose we start with a certain pulp containing a certain number of metallic particles, and you put in oil and put it through the process, and we find that we have not enough oil to give us what we want; the froth of that certain stability containing a certain number of metallic particles. If we had a little more oil we would approach the condition that we want, wouldn't we?

A. I don't know. I suppose you would bring out more particles and you would get a more stable froth.

X Q. 190. And there must be some condition when we get the maximum froth?

3114 A. No, I don't think so.

X Q. 191. You cannot conceive it?

A. I don't see any condition of maximum.

X Q. 192. And the more oil you put in the better the results is that right?

A. You will ultimately arrive at bulk oil flotation. You would not have bubbles if you put in oil enough.

X Q. 193. How much do you know of bulk oil flotation?

A I will answer again that I am not an expert in technical mat-

ters, and I am not competent to answer that question. I don't know.

X Q. 194. Can you conceive a condition where, having started with a certain pulp and added to it a certain amount of oil, enough to form a good froth containing ninety per cent of your concentrate, with that definite relation, and now you add a little more oil. What do you expect to happen then?

A. I suppose you might get a thicker froth, a froth which looked more oily, which might hold more oil than was absolutely essential, a non-economical use of the oil, some of which might be redundant, but as I stated, I don't feel that my opinion is competent, because I am not an expert in the actual operation. I am only stating my idea of what might happen; in other words, if I apprehend your question, there is an amount of oil, undoubtedly, that is too small to get any discoverable effect. One molecule of oil won't form an adsorptive layer, but I don't think that there is any maxi-
3115 mum there at which the flotation process would cease, before you get to bulk oil flotation.

X Q. 195. How about a minimum amount of oil?

A. One molecule.

X Q. 196. One molecule, you mean a layer of one molecule over every bubble?

A. No, I mean one molecule in your pulp; one molecule of oil might attach itself to one molecule of sulphide, and if you stir it around it might possibly come to the surface.

X Q. 197. That would not be a practical process of concentrating ores?

A. No.

X Q. 198. Now, let us get up to a practical process; can you give any opinion as to the practical processes of concentrating ores?

A. No, I don't know anything about the practice of concentrating. I am, however, sure that there is no dividing line in the amount of flotation. There may be different amounts of froths—different kinds of froths, some more stable and some less stable, some richer and some poorer, but that is a question for the experts in manipulation and is outside of my field. I have endeavored to explain how the thing occurs. The conditions under which it is to be carried out I don't know.

X Q. 199. Therefore your statement that there is no critical point is a statement based upon theory and not upon actual knowledge of the practice of the process?

3116 A. By the word "theory" I do not mean hypothesis. In answering that question when I used the word theory I mean a set of conclusions drawn from certain premises, experimentally established, these conclusions being reasoned out. My opinion is based upon theory as so explained, and my answer as given is in accordance with that.

X Q. 199½. Suppose I put a case to you of using one-tenth of one per cent of oil to the ore, and obtaining by it a concentrate of high grade with a ninety per cent recovery; that would be a practical process of concentrating ores, wouldn't it?

A. Why, I have heard it so stated; I don't know of the actual operation myself.

X Q. 200. Now, if you added two-tenths of one per cent, you would be using more oil than would be necessary, wouldn't you?

A. I judge not, from the testimony of the experts.

X Q. 201. From what testimony?

A. I understood Mr. Wickes to say that in many cases the use of a larger quantity of oil was very beneficial to the commercial results.

X Q. 202. Then you base it upon what has been said here about these wonderful operations, aiming to use twenty pounds of oil or more to the ton of ore?

A. No, I base it on my understanding of what actually happens in the flotation cell.

X Q. 203. Well, let us put it this way. Suppose you get a ninety-five per cent recovery with a high grade, and one-tenth of one
3117 per cent, or two pounds of oil to the ton of ore. Suppose you increase it to twenty pounds to the ton of ore and get the same grade and the same recovery. Is it your theory, that, comparing those two operations, the one using two pounds and the other using twenty pounds, and both getting the same results, that those operations are essentially and in all respects the same?

A. I would not say that the result was the same in every respect, but I would say that the process was the same in kind. It is the process that I am describing, and not the result.

X Q. 204. Would the concentrate froth be substantially the same?

A. There would be probably differences in the amount of oil detectable in the—on the surface.

X Q. 205. Most of the oil would go with the concentrate, would it?

A. That depends how much water there was and how much agitation was used and how much mineral was there.

X Q. 206. Let us take the case of two pounds.

Mr. Sheridan: I object, because the witness has not qualified as a practical mill operator. I have listened to it a long time. He is not a mill operator at all, and has not testified to mill operations, but simply to the physics of the phenomena.

The Court: I think so. He has assumed to testify how the process worked and the functions of these various materials used in it, but nothing——

3118 Mr. Williams: I respectfully submit that the witness has said that there is no such thing as a critical point, and that he has testified as to the process of concentrating ores. Consequently I am entitled to inquire rather fully as to that matter.

The Court: Well, proceed; we will see what the question is.

X Q. 207. Take the case of two pounds of oil to the ton of ore, where would you find the oil at the conclusion of the operation?

A. I don't know what the operation is that you contemplate.

X Q. 208. The operation of froth flotation concentration of ores; the agitation froth process or the pneumatic?

A. Again I say that I am not familiar with all the details of this

operation. I don't know what becomes of the tailings or what water is spilled or the various cells that carry the circulating load; I am not competent to answer that question; I don't know.

X Q. 209. Now, the case—take the case of a soluble frothing agent. This soluble frothing agent being dissolved in the ore pulp, is wholly distributed through the pulp, is it not, primarily?

A. That depends what degree of solution you use?

X Q. 210. Well, it is wholly dissolved; I am talking of it as a dissolved substance in the pulp?

A. Well, soluble substances do not dissolve without limit; there is a limit to solution, and the thing may be saturated and nothing may be dissolved.

3119 X Q. 211. I did not say soluble without the further qualification that it was wholly dissolved. Now we have dissolved in the pulp a frothing agent?

A. Do you mean dissolved in the water of the pulp?

X Q. 212. Dissolved in the water of the pulp if you will, a frothing agent?

A. Yes.

X Q. 213. Now, that is distributed uniformly through the pulp, is it not?

A. I don't know.

X Q. 214. Now, let us assume that you put in a soluble frothing agent and put it through the Janney emulsifiers, or the first agitator, then let it flow into the separation box or spitzkasten. That operation has brought about, has it not, the contact of every metal particle with the water containing the dissolved frothing agent?

A. I presume so; I don't know; I never watched it.

X Q. 215. If a particle of metal is in the water of that pulp containing a dissolved frothing agent distributed and dissolved in it, must it not be in contact with the water containing the dissolved frothing agent?

A. And no other oil or insoluble oil present?

X Q. 216. Yes.

A. I presume it would be.

X Q. 217. And has every bubble of air in that pulp not also come in contact with water containing the dissolved frothing agent?

A. I think it would depend somewhat upon the character of the frothing agent.

3120 X Q. 218. I am assuming a wholly dissolved frothing agent dissolved through the pulp. Now, I ask you if the air bubbles will not of necessity be in contact?

A. It would make a difference, it seems to me, whether the soluble frothing agent lowers the surface tension or raises the surface tension.

X Q. 219. I see—I think we have got far enough along to know that the soluble frothing agent, if a soluble frothing agent has to lower the surface tension, haven't we?

A. No.

X Q. 220. You have not reached that point yet?

A. No.

X Q. 221. Well, let us take a soluble frothing agent that does

lower the surface tension, if you wish me to put that as a qualification. Won't every air bubble be in contact, that is immersed in the pulp—be in contact with the water containing this dissolved frothing agent?

A. I am not sure. My opinion is it would depend on the character of the frothing agent, on the amount of the energy of the various interfaces.

X Q. 222. And when you get your concentrate with this dissolved frothing agent, where would you expect to find the dissolved frothing agent? You have floated off your froth and separated it, and you have in your spitzkasten the tailings—where will you find your dissolved frothing agent?

A. I am not even sure that this dissolved frothing agent would collect the mineral particles. You have got to specify the
3121 character of the frothing agent, whether it has any adhesion to the sulphide. All that has been said in my understanding of the question was that this substance was soluble in water and it produced a froth. Now, I am not sure that the sulphide will tend to migrate into these bubble films any more than the quartz does. We have got to study the character of the particular kind of frothing agent.

X Q. 223. Well, take acetic acid?

A. I don't know anything about that, but if you will permit me to specify another case, the case of saponin. If saponin is put in water it lowers the surface tension slightly with increased viscosity, and you get a very nice froth, but there is no essential adhesion between the sulphide and the saponin. A frothing agent like saponin does not, as I understand it, produce mineral separation of this kind.

X Q. 224. I see you have not adopted the terminology of the art—that is, the terminology of the art in the patents at least, that is a mineral frothing agent, and I intended always to describe a mineral frothing agent, a frothing agent that produced a selective mineral froth or selective froth?

A. In the case that you get a froth by such frothing agent, if you examine the froth or the concentrate as it comes up in the froth, I should expect to find a very considerable part of it in that interfacial film.

X Q. 225. And the concentrate would carry a great part of the dissolved mineral frothing agent?

A. I think so.

3122 X Q. 226. And the operation of the process would have robbed the pulp, you might say, of its dissolved frothing agent?

A. To a certain extent.

X Q. 227. You don't know to what extent?

A. I don't know to what extent. That is entirely outside of my field of investigation.

X Q. 228. Now, in your direct examination you said that in the agitation froth process of concentrating ores, oil above one per cent and oil under one per cent were the same, but you just made the

bare statement. Now, I would like you to put as fully and clearly as you can, your reason for that statement?

A. Well, in the theory in which I have outlined with the physical facts and principles to which we appeal in explanation thereof, I see absolutely no difference in the process of the operation.

X Q. 229. You recognize, as I understand it then, no difference in the process from a minimum of something less than a pound of oil to the ton of ore, up to the conditions of 200 pounds of oil to the ton of ore?

A. I can see no difference in the physical phenomena nor reason for a failure of the process.

X Q. 230. With 200 pounds to the ton of ore, would you expect to find that your froth was composed of air bubbles, and metal particles exclusively?

A. I have never seen cell operations with such large amounts of oil and I have no idea what would happen.

X Q. 231. What is the largest amount you have seen?

3123 A. I do not know. The amounts were not told me.

X Q. 232. What is the smallest amount you have seen?

A. You mean in mill operations?

X Q. 233. In mill operations.

A. The facts were not told me. I simply saw the machines operating.

X Q. 234. Your practical contact with mill operations has extended over what period?

A. It hasn't any extent. I have seen mills in operation, but I have no acquaintance and no competency to pass upon their operations.

X Q. 235. Can you conceive of a bulk oil float buoyed by air bubbles in it, like a sponge? Can you conceive of that as being produced by the use of oil, ore and water?

A. I never have seen the bulk oil operation and I am not able to answer that question.

X Q. 236. Can you give any theory as to the relation of the metal particles in such a bulk oil float, to the air bubbles in that float?

A. All I can state is that the metallic or solid particles would take up that position where their potential energy was least, and that can only be determined by experimental investigation. I think the chances are that if they were to reach the air-oil viscous layer, that they might have some difficulty in leaving it? But, further than that, I have not made any investigation on that point. I can not offer any intelligent opinion.

X Q. 237. Would the air bubble in that oil layer loaded

3124 with metallic particles perform any useful function other than to make a hole and diminish its weight?

A. I can not say; I have not seen it.

X Q. 238. Have you ever seen a float wherein there were oil bubbles and air bubbles, the oil bubbles and air bubbles existing in what looked like a froth but was not in fact an air froth?

A. I don't understand what you mean by an air bubble, or what by an oil bubble. What is the air bubble made of?

X Q. 239. The air bubble has a film about it.

A. Film of what?

X Q. 240. A film which I would say would contain some oil, and have you ever seen in the same float with that, an oil bubble?

A. I don't understand what an oil bubble is; how is that different from the so-called air bubble?

X Q. 241. Is it conceivable that there could be an oil globule in such a float?

A. A body of oil—a globule of oil might be surrounded with water——

X Q. 242. Well, now, that is a float where you have these floating bubbles with their oil adsorbed layer, and metal particles? Have you seen in such a float globules of oil?

A. No.

X Q. 243. Never?

A. No.

3125 X Q. 244. But I take it that your examination of what has been done in mill operations has been of such a recent nature that you really would not express an opinion?

A. I am not competent to pass upon mill operations of any sort or character.

Whereupon an adjournment was taken until Friday, April 27, 1917.

Friday, April 27, 1917—10:00 a. m.

FREDERICK E. BEACH resumed the stand for further

Cross-examination.

By Mr. Williams:

X Q. 245. Coming now, professor, to the scientific viewpoint, is it not scientifically certain that in the agitation process there may be an amount of oil so small that the process will not succeed?

A. I do not grasp all the question. Will the reporter please repeat it?

(Question read as follows: "Coming now, professor, to the scientific viewpoint, is it not scientifically certain that in the agitation process there may be an amount of oil so small that the process will not succeed?")

A. I don't think that I could specify any quantity of oil so small that it could not be conceded to exert some influence in
3126 bringing a sulphide particle to the surface in connection with an air bubble. I presume that there are quantities small enough so that the process would not be commercially acceptable.

X Q. 246. I will repeat the question: "Coming now, professor, to the scientific viewpoint, is it not scientifically certain that in the agitation process there may be an amount of oil so small that the process will not succeed?"

A. I have tried to answer the question as I understand it, that no matter how small the quantity of oil, the smallest quantity that I can conceive will be a molecule. Now, a molecule of oil might attach itself to a molecule of sulphide in this combination, namely an oiled sulphide particle might be entrapped in a bubble form and brought to the surface. Such a thing, scientifically, it seems to me is possible, but I repeat there may be a quantity of oil which is not commercially acceptable or useful. If I failed to apprehend your question will you please put it differently?

X Q. 247. Is it not scientifically certain that there must be under a given set of conditions other than the oil proportion, an amount of oil so small that a desired proportion of sulphide particles will not be included in the froth?

A. I understand that "desired proportions" have nothing to do with science. Science inquires as to what can or does happen. "Desired proportions" have to do with commercial values. I have tried to answer the question as I understand it. There is no minimum limit down to the molecule of the quantity of oil that I can
3127 see that would fail to operate. Whether this amount as small as a molecule of sulphide is desired or not hasn't anything to do with science.

X Q. 248. I will repeat the question, changing the word "desired" to "fixed"?

(Question read as follows: "Is it not scientifically certain that there must be under a given set of conditions other than the oil proportion, an amount of oil so small that a fixed proportion of sulphide particles will not be included in the froth?")

A. If we mean by "fixed" always under a like condition as far as we can produce it, that the same amount shall always be brought up, I should say that there would be, according to the theory of probability, sometimes more or sometimes less; but I cannot say that I see there should be any minimum limit to the quantity of oil fixed in any way than by the least quantity of oil known to science, namely a molecule.

X Q. 249. Is it not scientifically certain that there must be under a given set of conditions other than the amount of oil, an amount of oil so large that the process won't succeed?

A. What do you mean by the "process"?

X Q. 250. The agitation froth process.

A. The agitation froth process in mill operations I am not competent to answer.

X Q. 250½. I asked you about it scientifically. I didn't say anything about mill operations. I asked you for scientific facts.
3128 A. But you couple with it, as I understand it, a particular process which is a mill process. That process I am not familiar with.

X Q. 251. You have testified about the agitation froth process from a scientific viewpoint, have you not?

A. Yes, but that process involved the beating of air into a mixture of oil and water and sulphide and gangue. The physical phenomena,

physical result, of the process involved in that I have testified to. If by the word "process" you mean such an operation, I can say that I see no limit to the amount of oil which would limit the operation of this process which I have outlined, namely the adsorption of a sulphide particle at a surface, or in other words the migration of a sulphide particle into an interfacial film. The point of the question — I understand it is the fixed quantity of oil. The quantity of oil which is involved, for example, in that copper powder experiment has nothing to do with the entanglement of the metallic particle. In that experiment there was an inch of oil. The phenomena would have been absolutely the same if there had been a lake of oil a mile deep. I know of no upper limit to the amount of oil. I have tried to answer the question as I understand it.

X Q. 252. When you say the process is the same from a molecule of oil upwards is it your theory that, given the presence in water of the minimum quantity necessary to act in the way you have described, and given the necessary agitation and other condi-
3129 tions, it acts that way whether an excess on oil over and above that minimum be present or not present?

A. Well, I will try to answer the question as I understood you to put it. It is rather involved. If you have a molecule of oil and a molemule of sulphide, there are certain physical or if you prefer to call it chemical forces of attraction between those. The molecule of sulphide is drawn to the molecule of oil, or vice versa, and there is an adhesion or attachment between them, and they rise together, entangled in the film of an air bubble. I say that the operation of that law or that physical phenomenon is identically the same whether the number of molecules there is one of each, or whether the number of molecules of sulphide and oil are inconceivably great—infinite in number.

Mr. Williams: That is all.

Redirect examination.

By Mr. Scott:

R. Q. 253. When an air bubble in the bubble holder is brought in contact with an oiled-sulphide particle, is there any change in the distribution of the oil—by the bubble holder I refer to this little inverted cup.

A. May I illustrate that by a diagram?

R. Q. 254. Yes.

A. In my sketch let V represent a vessel containing some water as shown, with an upper horizontal surface. Suppose we try an experiment of this sort, that we have a stick of wood, a match
3130 stick, or suppose we have a needle shaped piece of metal or sulphide, that we dip that into the vessel of oil, and when the end of this rod or stick has been oiled that way, present this minute charge of oil to the liquid surface. If this oil was kerosene or creosote or pine oil, at the instant of contact of the oil point with the surface there is usually seen a flash of oil over the surface—seen by

reflected light you get the colors of thin films; the experiment is readily visible in that form. Note the condition; we have air on one side of the surface, the interface; we have water below and an oiled stick is brought in contact with that interface. Now, Mr. Scott, I understand that your question conceives a state of circumstances which do not essentially differ in their nature from this. I will try to represent that. Let U represent a glass vessel, and let this represent an oiled sulphide particle or particles which is underneath the surface of the water in this vessel. Suppose that you have a bubble holder such as was discussed in our testimony yesterday, and suppose that you have a bubble there filled with air; we have air on the inside, we have the interface air-water, and we have water. We are now bringing an oiled body in contact with an air-water layer. As far as the physical phenomena are concerned, the conditions are identically the same as they were here; air, water and oiled stick or particle, material of any kind. The physical phenomenon which happens there is a spreading or adsorption of the oil over the interface, and I have no question that there is a layer of adsorbed
3131 oil upon the interface of that bubble, just as here we find that when the experiment was completed we have an oiled layer or adsorption film in the upper figure. Have I answered the question that you asked?

R. Q. 255. I think so. That will be all.

Diagram marked No. 21 and offered in evidence admitted without objection marked Defendant's Exhibit No. 148.

Recross-examination.

By Mr. Williams:

R. X Q. 256. What is the thickness of the film which flashes over the water surface when the water surface or bubble surface meets oil as shown in your diagram?

A. I can not quote the figure, but I can quote from memory an authority in which you can find the statement of the measure value. In the popular lectures by Sir William Thompson, he was Sir William Thompson when the lectures were delivered; he has been since known as Lord Kelvin—and in, I think the first volume—I believe there are three volumes; one of the volumes has to do with geology, and one with navigation, and the first one has to do with certain phenomena of physics. I can not quite recall that, but I am pretty sure it is in the first volume of his popular lectures, that in one of those lectures he discusses the minimum thickness of a layer of oil which will respond to the camphor test. In an experiment of this sort, if you take perfectly clear water and drop on it little
3132 grains of dust of camphor, those particles are seen to move and dance around in a very erratic manner. A minute amount of oil will prevent the camphor from dissolving in the water, and the particles will be then at rest. In that lecture he has carried out a calculation to show what the least thickness might be. The upper limit, the maximum thickness there one can hardly state. If

you put on a large drop of oil, a certain amount of it spreads over the surface, and the rest of it gathers together in a little lens-shaped figure, and if you add more oil the lens increases its diameter, until the whole surface would finally become covered to any depth. There is no upper limit, but the smallest thickness that will respond to the camphor test can be found in that lecture. That is my recollection of one instance in the literature of physics that a definite statement is made in regard to the thickness of the oil.

Professor WILDER D. BANCROFT, called as a witness in behalf of the defendant, being first duly sworn, testified as follows:

Direct examination.

By Mr. Scott:

Q. 1. Professor Bancroft, will you please state your full name?

A. Wilder D. Bancroft.

Q. 2. I will ask you to state the character and nature of your education along scientific subjects?

3133 A. I have received an A. B. degree in Harvard in 1888. The next year I was assistant in general chemistry and also private assistant to Professor Jackson, doing research work in organic chemistry. The year after, 1889 to 1890, I did research work in organic chemistry at the University of Strasburg, working under Professor Fittig. From 1890 to 1892 I studied physical chemistry at the University of Leipsig under Professor Ostwald. I received my Ph. D. degree at Leipsig in 1892. The following winter I spent at the University of Berlin attending lectures on mathematical physics by Professor Helmholtz. In the spring of 1893 I went to Amsterdam and worked for about two months in the private laboratory of Professor Van 't Hoff. The next year, 1893 to 1894, I was an assistant in general chemistry at Harvard and I gave a private course of lectures on physical chemistry on the side. The next year, during Professor Cooke's absence, I gave a course of lectures on physical chemistry. I don't remember whether I was an assistant or an instructor that year. It was one or the other. From 1895 to the present time I have been at Cornell University as assistant professor of physical chemistry and professor of physical chemistry. I don't remember when I was appointed professor of physical chemistry. It was either in 1902 or 1903. I have had no technical experience.

Q. 3. You have referred to Professor Ostwald and Professor Helmholtz and Professor Van 't Hoff. Can you briefly tell us something about these men, what their line of investigation and authority has been?

3134 A. Ostwald was the man who really developed the modern physical chemistry. He founded the Zeitschrift fuer physikalische Chemie.

The Court: What is the name of that?

A. It would be in English the Journal of Physical Chemistry, but I cannot call it that because that is my journal. And he has been the leading figure in the development of physical chemistry. He

received the Nobel prize for his work on reactions, velocity and catalysis. I don't know what year he received it. Is that enough about him?

Q. 4. That is all concerning Professor Ostwald?

A. Yes. Helmholtz was an authority on everything. That describes him pretty thoroughly, I think. He began by doing work on the conservation of energy. He and Lord Kelvin were unquestionably the leading two physicists of their time. It is a matter of personal preference which you consider the greater. And he also did an immense amount of work in physiological optics and music and heaven knows what else. Van 't Hoff was the first man to do very much in the way of applying mathematical formulae to reaction velocities. His early work was in organic chemistry, where he developed the theory of the asymmetric carbon atom, which accounted for the optical rotation of carbon compounds. For the greater period of his life he was at Amsterdam. After that he was called to Berlin by the joint action, as I understand it of the Prussian government and the Prussian Academy of Sciences, a thing which has never happened to any man before in the world. When the
3135 Nobel prizes were given he was the first man to receive the prize in chemistry.

Q. 5. Have you been connected with any scientific organization?

A. Yes. I am a life member and an ex-president of the American Chemical Society. I was one of the original committee which organized the American Electro-Chemical Society. I am a member of that society and an ex-president. I am a member of the American Physical Society; I am a non-resident member of the American Academy of Arts and Sciences. I am an ex-vice-president of the American Association for the Advancement of Science, section C; I am a member of the Chemist Club of New York and an ex-non-resident vice-president. I founded the Journal of Physical Chemistry in 1896, and I have consequently been the editor of it ever since. I am associate editor of the Journal of the Franklin Institute. I was a member of the executive committee of the Eighth International Congress of Applied Chemistry. I was also chairman of the section on photography and photo-chemistry of the Eighth Congress of Applied Chemistry, and I am now the chairman of the sub-committee on electro-chemistry of the National Research Council in connection with the war.

Q. 6. How long, Professor Bancroft, have you been interested in the subject of flotation concentration?

A. Some time in 1906, presumably in the spring of 1906. I read the articles on the physics of ore flotation by Swinburne and Rudorf and on the concentration of metalliferous sulphides by flota-
3136 tion by Huntington. I cannot fix the date any more accurately than that because this number of the transactions of the Faraday Society purports to have been published in February, 1906, but these numbers come out at very irregular intervals and I cannot say now, eleven years afterwards, whether it came out in February or whether it came out in August; but I read it as soon

as it came and it presumably came in the spring of 1906. At that time I was not lecturing on anything to which these articles had any special application so that they rather went into abeyance, but when I took up a course of lectures on applied colloid chemistry this came in and in the autumn of 1912 I gave a lecture or a part of a lecture on flotation and I have done the same every year since then. In the beginning it was very little knowledge and mostly guess work, and since then there has been every year a little more knowledge and still a grat deal of guess work.

Q. 7. Now, how would you define or describe a froth?

A. A froth is a closely packed mass of air bubbles having a honeycomb structure with liquid films as the cell walls and with each individual cell filled with air or with other gas. That definition excludes things like aerated bread which I think should not be considered as froth.

Q. 8. Is it possible to obtain a bubble with a pure liquid?

3137 A. It is practically impossible to get a free bubble with pure liquid because the surface tension causes the bubble to break.

Q. 9. And what is necessary in order to practically produce a bubble?

A. You must have in there a third substance which will give a surface film which is more viscous than the mass of the liquid. It may be done then either by concentrating at the surface, which is the usual case, or in special cases by the third substance concentrating in the mass of the liquid, leaving the surface film more dilute.

Q. 10. What substances will concentrate in this way in a surface film?

A. All substances which lower the surface tension of the liquid will concentrate in the surface of the liquid, alcohol and acetic acid, to take two cases, and also any substance which is adsorbed strongly by air.

Q. 11. What effects do alcohol and acetic acid have on the surface tension of water?

A. Both alcohol and acetic acid lower the surface tension of water, and they lower that in all concentration. That is, if you add a little alcohol to water it lowers the surface tension, and as you go on adding more you get the surface tension lower more and more all the way down until you get to pure alcohol. In other words there is no point at which there is either a maximum or a minimum surface tension for any mixture of alcohol and water. The same thing applies for acetic acid and water. That is, we change the--

3138 that is, with changing concentration the surface tension varies continually from the surface tension of pure water to the surface tension of pure alcohol or pure acetic acid, as the case may be.

Q. 12. And what effect does alcohol and acetic acid have on the viscosity of water?

A. The addition of acetic acid increases the viscosity in all particulars with the changing condition of the acid, from the viscosity of pure water, which is less than that of acetic acid, to the viscosity

of acetic acid which is greater than that of pure water. Alcohol, however—and by that I mean ethyl-alcohol—behaves quite differently. The first addition of alcohol increases the viscosity of the liquid and further additions increase the viscosity up to a point—I do not know the exact figure, but approximately 47% alcohol. From that on, the addition of alcohol decreases the viscosity until you get down to the viscosity of pure alcohol. In other words, a concentration which is somewhere about 47 per cent of alcohol, you have a maximum of viscosity and that goes down on the one side to the viscosity of pure water and down on the other side to the viscosity of pure alcohol, so that it is an entirely different question as regards viscosity from the case of acetic acid; whereas, in regard to the surface tension effect the substances behave exactly alike.

Q. 13. What is the effect of the maximum viscosity in aqueous alcohol?

A. It has a very marked effect on the question of foaming. It is usually stated that aqueous alcohol solutions foam, but that
3139 is not correct, except within a certain limit of concentrations. Since the alcohol reduces the surface tension at all concentrations, it will always form an alcohol rich film in all aqueous alcohol solutions; on the other hand with concentrations with probably from a trace of alcohol up to 47% alcohol, the alcohol rich film will be more viscous than the mass of the liquid, and consequently we shall have conditions of foaming so that if we beat up any aqueous solution from a trace of alcohol up to 47% alcohol or thereabouts—I don't guarantee the absolute accuracy of the figures—the mixture will foam. If, on the other hand, you take a point beyond the maximum viscosity, from 47% down to practically pure alcohol, those mixtures will not foam. Whereas, in the case of acetic acid, where there is no maximum viscosity, all solutions of acetic acid from the very dilute ones up to those which are nearly pure acetic acid, will foam.

Q. 14. Can you show this by an experiment?

A. We have an experiment which will show that, and before I do that I would like to say one thing, that in all the experiments that I shall show, I shall of course give the weights which are used in each case, but the absolute values are of no importance whatsoever, because you will get exactly the same phenomenon over quite a range of concentration; for instance, in this experiment with alcohol, we are going to use 95% alcohol, because that is the form in which we buy it; but we would get exactly the same thing if we started with 99.5% alcohol and ran down to 50% alcohol; you can
3140 vary that proportion say 49% without affecting in any way the character of the result.

In some of the other experiments the range will not be so large, but the absolute values are of no importance whatsoever.

(Test No. 13.)

We have here a square glass jar, into which is poured about a quart of so-called absolute alcohol, which means as a matter of fact approximately 95% alcohol; it contains somewhere in the neigh-

borhood of 95% alcohol and 5% water. We shall then beat that up with—beat that up in this square glass jar and, if luck is with us, you will see that it does not foam much. The time of the beating is quite immaterial, so, in order to save time we will only beat it for thirty seconds, but if anybody wants it beaten longer we will beat it as long as anybody wants it done. We will have to wait a moment until the machine is started upstairs so we will have a current. While we are waiting I will also add that unless otherwise stated the rate of the stirring is always about 1,700 revolutions per minute. Now, I do not guarantee the absolute accuracy of that.

Mr. Sheridan:

Q. 15. Professor, do you know what the diameter of the plates are?

A. I have those here. The rectangular glass jar is approximately four inches by four inches by twelve inches high. We are using a four-bladed propeller, with blades approximately an inch and a half to the centers, and half an inch wide. The diameter of the propeller shaft is approximately half an inch, and the machine is
3141 driven by a quarter horse power motor. The machine being started, the belt slips off, but you will notice that it is not frothing. That is not important, because the thing had not got up speed. (Machine started.) You notice it is being started up vigorously. I push the switch and there is not anything that even could be called a temporary froth. The bubbles arise, and disappear at once.

(Test No. 14.)

We will now repeat this experiment, starting with 1,500 cc. of tap water and add about 10 cc. of the same alcohol, and stir it up about the same length of time.

By the Court:

Q. 16. This is to illustrate what?

A. This is to illustrate that in cases where we have a lowering of the surface tension, we may have either foaming or not foaming, depending on whether the surface film formed is more viscous or less viscous than the mass of the solution; in other words what I am trying to prove is that the important thing is to form a more viscous film at the surface. In the case of the alcohol beyond the concentration of 47% alcohol, the surface layer is less viscous than the mass of the liquid and consequently the liquid does not foam. For concentrations of alcohol up to about 47%, the surface layer is more viscous than the mass of the liquid and consequently the thing does foam. Of course that does not give a permanent foam. We will pour out about 10 cc. alcohol—as a matter of fact it is ten and a half—and we will add that to 1,500 cc. of tap water, and
3142 we will stir this as before, about 30 seconds, unless somebody wants it stirred longer. (Starting machine.) You can see the difference in the look of things already. (Stopping machine.)

And you see the condition—you see the difference in the behavior—you can see an inch or so of froth there, which of course is not permanent, but quickly dies down, but it is strikingly different from the other.

As far as I know, this experiment with a high concentration of alcohol has never been shown before to any audience. It was devised by my colleague, Prof. Briggs. If there is no further question we might leave this and go on.

Q. 17. Will you state whether salt solutions ever froth, and why?

A. A number of salt solutions will froth; for instance a 5% potassium chloride solution will froth, and Mr. Dosenbach showed in court the other day that a concentrated sodium chloride solution will also froth. This is interesting, because these salts all raise the surface tension of the solution, and therefore concentrate in the mass of the solution, leaving a water rich film or a salt poor film at the surface, and consequently one would normally expect these not to froth. As a matter of fact, however, potassium chloride, to take that instance, lowers the viscosity of the water, and consequently the water rich film is more viscous than the salt rich mass of the liquid and consequently we have a case precisely analogous to this one of the dilute alcohol solution, so that the behaviour of
3143 potassium chloride solution is accounted for in exactly the same way as we accounted for the behaviour of the alcohol poor solution.

Q. 18. Will you state why these froths that you have been discussing and have shown in the experiment are evanescent and die out?

A. The surface film is more viscous than the mass of the liquid, but the absolute viscosity is very low, and consequently these froths are evanescent, and as I showed in the case of the dilute alcohol solution, there is a very vigorous frothing, but it does not last at all.

Q. 19. What happens in the case of colloidal solution?

A. If we have a colloidal solution, such as soap or saponin, for instance, the surface film is very much more viscous than in the other cases, and consequently the froth is relatively stable. I imagine that everybody has seen soap bubbles. The foaming of beer is due to the colloidal proteins, and anybody who has ever poured beer into a glass knows that you get a foam which can be blown off. In the case of champagne I don't know whether there are any colloidal proteins, but certainly the content is low, and one gets under those conditions a bubbling which gives rise to a very evanescent foam.

Q. 20. What happens when one adds oil to water?

A. If we add enough oil we get a second liquid layer, just as in these cases which we saw yesterday; we have a layer of kerosene as a second liquid layer on top of the water. If the oil is
3144 more dense than the water we would get the second liquid layer with the oil at the bottom and the water at the top.

Q. 21. What classes of oils do you distinguish?

A. Why, I think it is profitable to distinguish between oils which are practically insoluble in water and oils which are more or less soluble in water. Of course there is no sharp dividing line, but that does not prevent a classification being useful. For instance, it cer-

tainly is a good policy in every-day life to distinguish between animals and vegetables, and yet there are organisms which it is very difficult indeed to place under that classification, because the two do merge gradually one into the other, although, for every-day life, most of us can tell the wild flowers from the birds.

Q. 22. How is it that a practically insoluble oil forms a foam?

A. When you add a practically insoluble oil to water it is usually adsorbed by the water and spreads out as a thin film. That thin film gives you largely increased viscosity as was shown the other day, and since this is a surface film which has more viscosity than the mass of the liquid, you will get foaming, as has been shown in the case of the dilute alcohol solutions and the 5% potassium chloride solution.

Q. 23. What would be the effect of adding too much oil?

A. If you add too much oil—that is if you add a small amount of oil it spreads out and gives you a very thin film over the surface of the water; if you add a little more oil—oleic acid, for in-
3145 stance, it draws away from the oiled film of the water and gives you a globule or drop of oleic acid standing up there; depending on how you do it; you may get one drop or you may get several drops.

Q. 24. What are non-frothing oils?

A. The very insoluble oils are often called non-frothing oils, but I think it would be better, perhaps, to put it around the other way, that non-frothing oils are always insoluble oils; kerosene, for instance.

Q. 25. Is a practically insoluble oil necessarily a non-frothing oil?

A. No, I think not, because you might have a case where the oil adsorbed air very markedly, in which case it probably would give a good froth in spite of the fact that it was a practically insoluble oil.

Q. 26. What happens with moderately soluble oils?

A. With moderately soluble oils you get two effects; assuming that you add enough so that you get your second liquid layer—you get first the effect due to the second liquid layer, which is the same in nature as the effect of insoluble oil; you will also get a much greater effect—at least I think it is much greater—due to the dissolved portion of the oil, which will give you much more froth.

Q. 27. What are frothing oils?

A. Frothing oils as usually defined are oils which are either partly soluble in water or which contain a soluble or partly soluble constituent, and which show more or less selective adsorption for minerals.

3146 Q. 28. What is the relation between a frothing oil and a non-frothing oil?

A. They pass continuously one into the other; you might have different oils—hypothetical ones—which are soluble say, 10% in water, 1% in water, 1/10 of 1% in water, 1/100 of 1% in water, and 1/1000 of 1% in water. Certainly the one that was soluble only to the extent of 1/1000 of 1% in water would be classed as an insoluble oil. Equally certainly the one that was soluble 10% in water would

be classed as a frothing oil. Where you would draw the line in the other cases is perhaps a matter of personal preference.

Q. 29. Would you name a few instances of what would be classified as frothing oils?

A. Pine oil and eucalyptus oil can be taken as two instances of frothing oils.

Q. 30. What is the relation between a frothing oil and soluble frothing agents?

A. They pass continuously one into the other. If the frothing oil increases sufficiently in solubility, or if you take so little of the frothing oil that it is completely dissolved, it then becomes identical practically with the soluble frothing agents.

Q. 31. What are soluble frothing agents?

A. Soluble frothing agents are substances which give rise to a more viscous film; that is to say, in order to be a frothing agent they have to do that. They may be substances like alcohol and acetic acid that are miscible in water in all proportions under
3147 the conditions of the experiment. They may be substances like amyl acetate, phenol, aromatic hydroxy compounds, which are only partially miscible in water, or they may be substances like salt, which has a definite solubility in water, and then precipitates in a solid form.

Q. 32. Is saponin a soluble frothing agent?

A. Saponin might be called a soluble frothing agent, except for the fact that it plays havoc with flotation and consequently is usually excluded from it. I noticed that yesterday Mr. Williams elected to call these things mineral frothing agents, meaning thereby that these frothing agents showed a greater or lesser selective adsorption for mineral with respect to gangue. There is absolutely on objection to that definition as long as one understands what it means; on the other hand, it is a little better, I think, to say soluble frothing agents, and to note that we are not counting in saponin and things of that type.

Q. 33. Is there any sharp dividing line between non-frothing oils and frothing oils? and soluble frothing agents?

A. There is no sharp dividing line. I pointed out that you can start with practically insoluble oils and range continuously into a partially soluble oil, and may change continuously into a so-called soluble frothing agent. On the other hand it is a very useful classification for the purposes of discussion.

3148 Q. 34. How would you classify phenol?

A. Phenol is a good illustration, because it has been classified in two different ways. Dr. Adolf Liebmann said that when you add a small amount of phenol so that it is all dissolved in the water, it is a soluble frothing agent; but if you add an excess of phenol, it is an oil, and therefore, of course, would come under the head of partially soluble oils. That is perfectly legitimate as far as I can see, provided you choose to define things this way, and shows that there is no arbitrary dividing line between a soluble frothing agent and a partially soluble oil; because in this particular case it

has been classified, at any rate, as one or the other, depending on the relative amounts of phenol to water.

Q. 35. Are these general relations true of other liquids than water?

A. The whole discussion has really been general; I have used the word "water" because it is more convenient than to talk about liquid A and liquid B; but the relations are true of any liquid where you have formed a more viscous surface film; as a matter of fact the crude vegetable oils, to take a single instance, do froth when shaken. I have never tried that in the square jar machine, but I imagine it would be a gorgeous experiment.

Q. 36. Do they froth more readily than the refined oils?

A. The crude vegetable oils froth distinctly more than the refined oils, because they contain more colloidal material, which has
3149 been removed to a greater or lesser extent by refining; and as a matter of fact Baskerville points out that this frothing may be used as a qualitative test to show something in regard to the degree of refining.

Q. 37. Is the frothing of the oil important in the flotation process?

A. I think not. As far as I know, it is not; it does not come in anywhere, because under ordinary conditions the amount of oil used is relatively small in comparison to the amount of water.

Q. 38. What kind of bubbles does one get in the case of froths with oils or soluble frothing agents?

A. You get under all conditions a froth which is either an oil layer or an oil rich solution next to the air. In making that statement I am using the word oil in its broadest sense, to include soluble frothing agents.

Q. 39. How can a froth be made more stable?

A. Since the instability of the froth is due to the low viscosity of the cell walls, it can be made more stable by adding something or other which will increase the viscosity of the cell walls, or of the films constituting the cell walls.

Q. 40. What would be the effect of adding a viscous non-frothing oil?

A. If one adds a viscous non-frothing oil in suitable amounts, one may easily stabilize the froth. As a matter of fact that can be done with the so-called oil mixture of the Butte & Superior Company.

3150 That oil consists of 70% fuel oil, which is a viscous oil, 12% kerosene and 18% pine oil, which is a frothing oil. I made one experiment in which 4.5 gms. of this oil was added to 1500 cc. tap water at about 25°. There was also added one cubic centimeter concentrated sulphuric acid. The resulting mixture was stirred for thirty to ninety seconds, in different experiments, at about 1700 revolutions per minute in the square jar machine that you see there. And a fairly permanent froth was obtained about three-quarters of an inch thick.

Q. 41. Can you stabilize a froth in any other way?

A. A much more amusing way of stabilizing a froth is by adding a solid to it.

Q. 42. What solids will stabilize the froth?

A. Any solid which is adsorbed by the oil layer, by the oil-water interface, or by the oil-rich film, will stabilize a froth more or less completely.

Q. 43. What is the effect of lycopodium powder with water and pine oil?

A. We tried an experiment with that. We showed first that water and pine oil when stirred give no permanent froth. There is a temporary froth but no permanent one. We showed that water and lycopodium powder when stirred together give no permanent froth. We showed that water and lycopodium powder give no permanent froth and that the lycopodium powder becomes distributed throughout the mass of the water coloring it yellow. If, however, you take 1500 cc. tap water, 1 cc. pine oil, and 8.3 gms. lycopodium, put — in the square jar machine and stir for about thirty seconds you get a
3151 solid, yellow, very dry, permanent froth about 1.5 inches thick. The water is slightly cloudy, but not much so. In other words, pretty nearly all the lycopodium powder has gone up into the froth.

Q. 44. Will you show us that experiment?

A. In order that you may see that you get no permanent froth with the lycopodium powder we will put the lycopodium powder into the water and beat that for thirty seconds first. I take it that all of you know that pine oil does not give any permanent froth with water. (Test No. 15.) You see that there is no permanent froth and that the mass of the liquid is cloudy and colored yellow. Now, we will add about 1 cc. of pine oil and stir again. (Test No. 16.) You see that we get a relatively thick froth and that the mass of the liquid is no longer colored yellow and is only faintly cloudy. Practically all the lycopodium powder has gone up into the froth. I may state also that this experiment has never been shown before to an audience, so far as I know.

Q. 45. What is lycopodium powder?

A. Lycopodium powder is the spore of something or other, of either a moss or a fern, I don't know which. I think it is a fern.

Q. 46. Vegetable matter?

A. Oh, yes, it is vegetable matter, organic matter. It is a seed. I so understand.

Q. 47. What is the effect of white lead?

A. We tried an experiment with white lead, which is basic
3152 lead carbonate and when water and white lead are stirred together there is no permanent foam. The white lead is distributed all through the mass of the liquid, and makes it a very opaque white. When, however we take 1,500 cc. tap water at about 25°, 48 gms. of white lead and 1 cc. of pine oil and stir the mixture for half a minute or more we get a stiff froth. It makes no difference whether the pine oil be added to the water before the white lead or afterwards. That is, the order of mixing is immaterial. A great deal of the white lead is not carried up by the oil and the water consequently remains opaque and milky. In the case of the lycopodium powder practically all of the lycopodium powder was carried up by the oil. That was not the case with the white lead experiment.

Q 48. Can't you perform the white lead experiment?

A. I think so. I hope so. (Experiment No. 17.) You see that there is no permanent froth and the white lead is dispersed apparently uniformly through the mass of the liquid. We will add 1 cc. approximately of pine oil. (Experiment 18.) That ran about thirty-five seconds. You see that we get a very pretty, thick froth, and that the solution now is not entirely clear. I may say also that so far as I know this is the first time that this experiment has been shown to any audience. I should like also to add one statement in regard to the previous experiment with lycopodium powder. Mr. Williams has just told me that Mr. Higgins has done that experiment before. As Mr. Higgins had not told me about that,
3153 of course I made the statement that I did not know that it had ever been done before. If I had known that Mr. Higgins had done it I would not have bothered to carry the thing through myself.

Q. 49. Will white lead stabilize the alcohol foam?

A. In experiments that we have made we get no stabilization. When you stir a dilute solution of alcohol and water as was shown in the second experiment you get a frothing which is not permanent. When you add white lead and stir, the frothing is also not permanent, although it looks as though the alcohol froth did not break down quite so rapidly. To make sure of that one would have to follow it carefully with a stop watch which I have not done because I don't care anything about it. The trouble seems to be that the white lead is not adsorbed by the alcohol and consequently does not get into the film. Of course if it doesn't get into the film it can't act as a stabilizer, by definition.

Q. 50. And what is the effect of alcohol and kerosene with white lead?

A. We ran the whole set. Alcohol and white lead and water give no permanent froth because the white lead does not go into the alcohol film. Kerosene, white lead and water give no permanent froth apparently because kerosene is a non-frothing oil. In order to be sure that there was no mistake anywhere we tried a mixture of alcohol, kerosene and water. That gives no permanent froth. In other words we have tried our three combinations. Then we tried a
3154 mixture of alcohol, kerosene, water and white lead. We took 1,500 cc. of water and 4 cc. of kerosene, 10 cc. of 95% alcohol, and 20 gms. of white lead. These we stirred for a minute or two and a good stiff froth was obtained. The water was still milky because the white lead does not go up completely into the films.

Q 51. Can you show us that experiment?

A. Yes, sir. (Experiment #19.) We have shown you that alcohol and water give a froth which is not permanent. We do not need to show you that kerosene and water do not, because kerosene, by definition, by general acceptance is a non-frothing oil. We will now show you that a mixture of kerosene, alcohol and water as stated does not give a permanent froth. You get an evanescent froth. It is practically all gone except a few stray bubbles already.

The Witness: We will now add white lead, (Test No. 20) 20 grams of white lead, and we will stir this froth approximately a minute. (Stopping machine.) It is not a very striking experiment; something or other went wrong.

By Mr. Williams:

Q. 52. Tell what you got for the sake of the record.

A. For the sake of the record I will state that there is a very thin line of a froth scum at the top; nothing like what I hoped or expected or thought it should have done. We will start the motor again and see what happens. (Running motor again.) Well, the laugh is on me temporarily. If it is permitted, we will show
3155 that experiment again when it will work. Something has gone wrong, I don't know what, but it seems to be another instance where the experiment has failed but the principle remains the same.

The Court:

Q. 53. It is not a question of doing it here, is it?

A. Oh, no; it is simply a case that when I did the experiment before it worked, but in many of these things a very slight change makes a difference. It may be it would have worked better if we had put all the things in at once and had stirred them. In the case of the previous experiment with the pine oil and the white lead, I made actual determinations, that the order of adding made no difference; I don't remember whether I did in this particular case, and that may be the difficulty and it may not.

Q. 54. What are you trying to illustrate?

A. I was merely showing another instance of the fact that one can stabilize by means of a solid, and that this is rather an interesting case, because we had here a so-called non-frothing oil, kerosene, and a so-called frothing agent, alcohol, and that under those conditions we were to duplicate the ordinary practice of a froth stabilized by mineral, using a substance which does not occur in nature as a mineral; merely to show that the general principle was the same, that any solid which comes up under the circumstances into the film will stabilize it. The question of the success or failure of the ex-
3156 periment is absolutely immaterial, except that one likes to have them go.

Mr. Scott:

Q. 55. How does lycopodium powder behave with kerosene and alcohol?

A. Lycopodium powder with kerosene and alcohol gives, or gave, a good stable froth. I have tried 1,500 cc. of tap water, 10 cc. of alcohol, 2 cc. of kerosene and about 3 grams of lycopodium powder. After stirring from 30 to 90 seconds a good froth was obtained, which was approximately ⅜ of an inch thick, and the water was somewhat cloudy.

Q. 56. Will you show us that experiment, Professor?

A. No, I think not, thank you.

Q. 57. Can you stabilize alcohol froth with lycopodium; were you speaking of lycopodium and alcohol?

A. I am not ready to show that; it is not the one that I want to show. After that we went back and tried to see if we could stabilize alcohol froth with lycopodium powder, and it worked fairly well; that is, we took 1,500 cc. of tap water, 20 cc. of alcohol and anywhere from 8 to 12 grams of lycopodium; they were stirred for about a minute, and we obtained a pasty froth about half an inch thick. The interesting thing about this experiment—when it works—has been—so far it worked every time, but I don't guarantee anything in future—has been that the whole of the lycopodium powder goes up into the froth, and the water below is absolutely clear and
3157 colorless. It is not a tremendously successful experiment as regards the getting of a permanent froth, because the alcohol evaporates readily from the bubbles, and consequently the froth breaks down in the course of time. I shall be very happy to show you that experiment; that is the one that I think you asked for.

Whereupon an adjournment was had until 2:00 o'clock p. m. Friday, April 27th, 1917.

Friday, April 27th, 1917—2:00 p. m.

By Mr. Scott:

Q. 58. Mr. Bancroft, do you wish to repeat the experiment illustrating the effect of white lead upon alcohol and kerosene in the water? I think it was given #20.

A. (Repeating test #20.) You see we have a thick, stable froth about an inch thick, and the water is still cloudy below it. The trouble with the previous experiment apparently was that we added too little white lead and too much of it stayed down in the water to enable us to stabilize the froth satisfactorily. We ran the thing after the close of court by simply adding more white lead to the thing that had failed and it worked. In this particular one, as a matter of fact, I have changed the proportions as given before so as to play safe, and I will read what this experiment actually was. 1,500 cc. tap
3158 water at 25°; 10 cc. 95% alcohol; 6 cc. kerosene; and 48 gms. white lead. It is a little more kerosene, half as much again and more than double as much white lead. While I was a student in Germany I used to go to the opera and the first performance that was given they advertised it in large letters as "First Performance." For the second time they advertised "First Performance Repeated." And, consequently then, this is the first time that this experiment has been shown to an audience with failure and also the first time it has been shown with success.

Q. 59. You stated just before recess, Professor Bancroft, that you could stabilize an alcohol froth with lycopodium. Will you show us that experiment?

A. Yes, I will show that also.

Q. 60. Before you do that I would like to ask you a question about

this one you just performed and that is why this mixture stabilizes, having the white lead in it, when kerosene or alcohol alone will form a stable froth?

A. Well, kerosene is a non-frothing oil, so-called, which means simply that it does not froth readily. It, however, does hold or carry the white lead, the alcohol will froth, but apparently has no carrying power for white lead. By mixing the two, we get the good properties of both. The reason for putting on this experiment was merely to show that we are getting with a mixture, and in technical practice I understand that they do use mixtures a great deal,
3159 we are getting a stabilization without using any of the regular minerals. There is one thing that it perhaps might be worth while to say about the kerosene, and that is that kerosene would be classed essentially as a non-frothing oil. That does not mean that it does not froth at all, but that the froth is very instable and breaks down very readily, but of course if you had a substance there which was adsorbed very much by the kerosene, as you may have with several minerals, then under this condition you could build up a froth. I do not mean to say that in any way you could not build a permanent froth with kerosene if you had a suitable solid, because as a matter — fact people have done it.

The other question was the one about the alcohol and the lycopodium?

Q. 61. Experiment showing the stabilization of an aclohol froth with lycopodium.

The Court: I suppose we can assume that all of these experiments are to serve some useful purpose?

Mr. Scott: The experiments are to show the real facts of the frothing, that is to what the stabilization of a froth is due, and I think Professor Bancroft will sum up after a few answers the exact conclusions for which these experiments are the foundation.

A. In the experiment in the stabilization of alcohol froth by lycopodium powder we use 1500 cc. tap water at about 25°; 10 cc. 95% alcohol, and about 12½ gms. of lycopodium. And if it works well we ought to get a pasty froth and as I said the solution, the
3160 liquid below, should be almost absolutely clear. We have 1500 cc. of water now in there and we will add the lycopodium powder and the alcohol.

(Test No. 21.)

The Witness: You can see that that one works as per schedule.

Q. 62. Can you stabilize an acetic acid froth?

A. Yes, acetic acid has been stabilized by mineral at one time by Mr. Dosenbach, and we can stabilize it, using an entirely different substance than has been used before, by putting in lamp black.

Q. 63. Have you an experiment to illustrate that?

A. Yes, we have an experiment to illustrate that.

Q. 64. We will have you perform that one, then.

(Test No. 22.)

A. A preliminary run was made with water and lamp black, to be sure that we did not get froth with lamp black alone, so we took 1500 cc. of tap water and 1 gram of lamp black and stirred them in the machine and we got no froth. The lamp black seems to be distributed uniformly throughout the liquid, except that there are a few patches of thin skin on the surface of the liquid. I imagine that the lamp black is not absolutely pure, as lamp black never is; but so long as one does not get a froth with it, it makes no difference in the principle of the experiment. Then I added acetic acid, 10 cc. of 99% acetic acid——

(Test No. 23.)

99% acetic acid is the form in which it is bought from the
3161 druggist—and you get a stable, coarse froth, and the acetic acid does not take up all the lamp black, and consequently the body of the liquid remains black.

We have now the water and the lamp black alone. (Running motor.) You see you get a few bubbles which die down at once, and you see the whole mass of the liquid is black. Of course one might have known that it would be, because India ink is made of suitably prepared lamp black, and that dissolves in water. Now we will add 10 cc. of 99% acetic acid and stir again. (Running motor.) It has been stirred for 60 seconds. We get, under those circumstances, a very small amount of froth; we ought to have got more, but we didn't. We will stir it again. (Running motor.) It looks again as though there probably were not quite enough lamp black in it. Not quite enough lamp black and it does not work well, would seem to be the record for that experiment.

Mr. Williams:

Q. 65. Won't you state for the record what you see there.

A. Oh, certainly. The result of the experiment is not a success. There are only a few bubbles which are distinctly not permanent. We are running in rather hard luck.

Mr. Scott:

Q. 66. Would more lamp black make it better?

A. Unquestionably.

Q. 67. Would it be worth while to repeat it?

A. If it were for the sake of the experiment I would put
3162 in more lamp black and run it; but that is for you to say. If we put in more lamp black it will stabilize it, that is certain.

Q. 68. Suppose you do that and see the effect of adding more. How much did you put in before?

A. Well, another gram ought to do it without any trouble; it looks as though it ought to have done it there.

(Test No. 24, adding more lamp black.)

Now, adding one more gram of lamp black, making a total of two grams, and you get a fairly deep froth made of relatively large, coarse bubbles.

Q. 69. The froth is about how deep would you say, two inches, or three?

A. It is an inch and a half, I should judge, on an estimate. If anybody has a rule we can tell more closely.

Mr. Williams: I have a rule.

A. I will let you measure it; any measurement you take is satisfactory.

Mr. Williams: Something a little less than two inches.

A. That is more than I should have given it myself.

By Mr. Williams:

Q. 70. In speaking of it as a coarse froth, as I look at it the bubbles seem to be an inch or so across, many of them.

A. At the top, the upper bubbles are very large, and the lower bubbles are smaller.

Mr. Scott:

Q. 71. What effect does lycapodium have on an acetic acid froth?

3163 A. Lycopodium does not stabilize it, whereas lycopodium will stabilize two of the others that we have tried. It has no effect or practically no effect on acetic acid, showing that it is a question of selective adsorption, and not of any one substance being necessary to stabilize it.

Q. 72. Can you show that easily?

A. Yes, I can show that.

(Test No. 25.)

A. In this experiment we put in 1500 cc. of tap water at about 25°, 10 cc. of 95% acetic acid, and about 8 grams of lycopodium powder, and stir for 60 seconds.

A. The foam dies down fairly rapidly, the last part of course going more slowly and leaves just a mere line of lycopodium powder along the top, and nothing in the way of a deep or stable froth.

Q. 73. What effect does white lead have on phenol froth?

A. We tried phenol with white lead. I can give you the actual figures. When we took 1500 cc. of tap water, 2½ grms. of phenol, 10 grms. of white lead, there was no sign of any stabilization and consequently we did not go on and add more white lead because the bubbles showed absolutely no signs of being coated and it seemed perfectly hopeless.

Q. 74. Can you stabilize the phenol froth without using mineral?

A. Yes, you can do it by adding lamp black. In the experi-

3164 ment as I carried it out at first we took 1500 cc. of tap water at about 25° and 2½ gms. of solid phenol and added 1 gm. of lamp black and stirred and it gave us a very coarse froth. In

view of the way in which the lamp black acted the last time I have had another gramme weighed out and so we add at first one and will add another one if necessary. (Experiment #26.) About 60 seconds. We get a small amount, a quarter of an inch perhaps of a coarse black froth. I can get more by adding another gram of lamp black if desired, but it merely takes up time, hardly worth while.

Q. 75. You might, as you have the mixture here, add another gram?

A. (Repeating experiment #26 with the addition of one gram of lamp black.) About sixty seconds. That gives 1½ to 2 inches of a coarse black foam.

Q. 76. Now, do these experiments show the general theory of frothing to hold good?

A. I think they do. I think they show that the general theory as outlined holds in every detail and enables us to predict what will happen in case of the addition of these stabilizing agents, and that this theory holds for any liquid or any combination of liquid.

Q. 77. What is the state of things in the cell wall of these froths?

A. The cell walls therefore have a layer of oil or oil-rich solution next to the air in all cases, and the cell walls are stabilized by the presence of the adsorbed solid material.

Q. 78. Is there any relation between oil and the total solids in these experiments?

3165 A. In some of them there was absolutely none because in the experiments where there are no solids in at all of course you cannot speak about the relation of oil or soluble frothing agents to total solids, because it is meaningless. It could be figured out as a million, ten million or one thousand million per cent, just exactly as one would wish to do it.

Q. 79. Is the nature of the froth always the same when no solids are present?

A. The nature of the froth is always the same when no solids are present and consequently of course there cannot be any critical point under these circumstances and so far as I know nobody has ever claimed the existence of a critical point when one had oil and water alone. I use "oil" of course in the broad sense.

Q. 80. What is the effect of a solid?

A. The effect of a solid is to stabilize the froth by making the cell walls more viscous.

Q. 81. And that was the effect of the solids you used in this experiment?

A. Yes, that is the effect of the solids used in this experiment, and as a matter of fact we have used in there lycopodium powder, white lead, lamp black, and of course everybody else has done it with mineral, showing that the nature of the solid is absolutely immaterial except in so far as it determines whether it goes into the film or not. But once you get a solid into the film then it increases the viscosity and makes the thing stable.

Q. 82. Was the effect of these different solids known before?

3166 A. I had supposed that it was not. I did not know until today that anybody had ever tried lycopodium powder as a

stabilizing agent for froth. I know of no record of it in the literature and I did not know of anybody except this case of Mr. Higgins which he did not report to me, naturally—of anybody stabilizing a froth with lycopodium powder or with white lead. The lamp black I imagine has been used.

Q. 83. Do you consider that these experiments prove the correctness of the theory?

A. Why, it is usually accepted as a very satisfactory test of the theory that it enables you to predict results which have not been obtained before. That does not mean that you might not predict results which you cannot perform by means of a theory that is not right, but you can't keep it up long without getting caught.

Q. 84. What is your conclusion in regard to the type of froths?

A. That since the action of the solid is simply to stabilize the film by increasing its viscosity, there is therefore no change in the type of froth due to the addition of solid and consequently we have the same type of frothing process that we have when we have oil and water alone; in other words, a froth with an oil layer or an oil-rich solution next to the air. Always, as I said, using "oil" in the broad sense to include the soluble frothing agents.

Q. 85. Are these froths of the same type regardless of the ratio of oil to stabilizing solid?

3167 A. They are absolutely.

Q. 86. What ratio of oil to the stabilizing solids have you obtained in these experiments that you have performed?

A. Taking these data that I have one can calculate out a number of results. That is, where a stabilizing solid was used without any gangue, good results were obtained with 1 cc. of pine oil, specific gravity about .93 and 8.3 gms. of lycopodium powder. That is the experiment that was shown. That is a percentage of oil to solid of about 11%, in round numbers. Then, in the case of the white lead and the pine oil we had 4 cc. of pine oil and 48 gms. of white lead, a percentage of oil to solid of nearly 8% in round numbers. Then in the experiment with the alcohol, kerosene and white lead, the one that worked, we had 10 cc. 95% alcohol, 6 cc. kerosene and 48 gms. white lead, a percentage of kerosene and alcohol to white lead of over 25% in round numbers. In the case of acetic acid and lamp black we had 10 cc. of 99% acetic acid and 1 gm. of lamp black. That would be a percentage of acetic acid to lamp black of one thousand, in case you take the acetic acid as having the same specific gravity as water. As a matter of fact I think it is slightly denser, which would run the ratio of oil, meaning acetic acid, to total solid up to something over one thousand per cent; but I don't see any advantage in calculating that any more closely.

Q. 87. What conclusion do you draw from these experi-

3168 ments in regard to the froths made in the presence of mineral?

A. Why, that since the froth is stabilized by the mineral in exactly the same way that it is by the lycopodium or the white lead or the lamp black, that the froths which one gets when working with ore

are exactly the same type as the froths that we have made here with white lead and lycopodium and lamp black, and we could have gone on and increased that number indefinitely, if there had been any need of it—consequently I cannot see how there can possibly be any critical point at a ratio of .5% oil to ore or thereabouts; I cannot see that we have any possibility of a so-called critical point in there anywhere.

Q. 88. Can you illustrate that by experiment, the absence of any critical point?

A. Yes; we have three experiments which I will now show, and which are the last three, where we will take different amounts of oil to ore. The froths made with anywhere from one-tenth of one per cent. of oil upward. They look exactly alike, they behave exactly alike in mill practice and they are theoretically exactly alike. We will show three, one carrying in round numbers .3% of oil, one in round numbers 1%, and one somewhat higher, and I hope that they will all look very much alike; they certainly do when we ran them in advance.

(Test No. 27.)

The conditions of the first experiment are, 1500 cc. tap water at about 30°; one cc. concentrated sulphuric acid; 300 grams
3169 Butte & Superior ore, which I am told contains about 17% of mineral—I am taking the ore as it is given—and we add to that one cc. of oil mixture. I have given the composition of the oil mixture in my testimony this morning, and I am told that the specific gravity of that is about .87, and for our purposes we might call it .9, or we might call it 1., without introducing any error of any account; that is, in this first case, as we have one cc. of oil mixture to 300 grams of Butte & Superior ore, we have got something under one-third of one per cent of oil to ore, barring mistakes in weighing. We will stir each of these for three minutes at about 1700 revolutions per minute. This is one cc. of the oil mixture.*

Mr. Williams:

Q. 89. Did you figure the percentage of oil to ore?

A. It is something less than one-third of 1%. It would be one-third if we called the specific gravity of the oil one; it would be a little less than that if you call it .87. It would be just about .29 of 1% of oil to ore.

(Running motor.)

Just about three minutes.

Mr. Williams: We will want a specimen of this froth for analysis. I suppose we can arrange to divide the froth as we have in cases before?

The Witness: That is for Mr. Scott to decide. As far as I am concerned you are welcome to the whole of it.

Mr. Scott: You can have samples of the material, and if

3170 you wait till we are through you can have samples of the froth.

The Witness: I think we had better have all three of them set up side by side.

Mr. Scott:

Q. 90. I thought you were going to make all three in this one jar. A. Oh, dear, no; because then people might forget that they looked alike. This is .29% oil to ore.

(Test No. 28.)

The next experiment will be exactly like this one, except that we will add 3 cc. of oil mixture, instead of one cubic centimeter. That will give in round numbers a ratio of oil to ore of .87%, in case you take the specific gravity of the oil mixture as .87. To run it up or down a little will run the percentage up or down also. I have not determined the density of it, myself. This will also be run three minutes, exactly the same as the preceding one, the only difference in the experiment being in the difference of the ratio of oil to ore.

(Running motor.)

About three minutes.

(Test No. 29.)

The third experiment of this series, and the last one to be shown today as far as I know, is the same as the other two, except that 5 cc. of oil mixture are added instead of 1 cc. in the first case and 3 cc. in the second. If we take the specific gravity of the oil mixture at .87, that figures out in round numbers 1.45% of oil to ore (running motor). About three minutes. I think it will take an 3171 expert to see any fundamental difference between those three froths.

Mr. Williams: Now, Mr. Scott, may we have specimens of each of these froths, after court has adjourned?

Mr. Scott: It will only take a few minutes, your honor, to supply these samples, and I think we may as well do it now.

Mr. Williams: I would just like to call your attention also to the showering of the zinc in this last froth.

Mr. Scott: You have been stirring it?

Mr. Williams: No. The showering of the globules of zinc, that came down, as shown there at the very beginning. Your honor did not see that side of it. It is a little plainer there than anywhere else.

Th Court: You mean that it has fallen down?

Mr. Williams: That the zinc has fallen from the froth down and mixed with the gangue.

Mr. Scott: There is the same thing there in each one of these others (referring to each of the three samples).

The Court: No objection to taking these samples now if you desire.

Mr. Dosenbach: I am afraid if I mix them up I can't tell which is which.

Mr. Scott: I don't remember how they were put up.

3172 Mr. Williams: That is perfectly clear. This is the last.

The Witness: If your honor please, I should like to correct one statement which apparently was in error. I understood that this Butte & Superior ore had a mineral content of about 17%. I am told now that as a matter of fact this particular ore runs about 12.2 mineral. That makes absolutely—has absolutely no effect on the experiment because we are weighing out 300 gms. of ore and the ratios as given are of oil to ore.

Mr. Sheridan: 12.6 zinc.

The Witness: All right, we will get it straight somehow. I am now told that it is 12.6 zinc. It has no bearing one way or the other except I would like to have it straight.

Mr. Scott:

Q. 91. Is there any reason why a soluble frothing agent should not in itself produce separation?

A. There is no theoretical reason why a soluble frothing agent might not be used by itself to produce separation; and cases of that sort are known.

Q. 92. In which separation has been produced?

A. In which separation has been produced by the use of the frothing agent alone.

Q. 93. What is the objection to using soluble frothing agents alone?

—. As a general thing the adsorption of the frothing agent by the mineral is not very marked and consequently the flotation is

3173 not as satisfactory as one would like in most cases.

Q. 94. And how has the difficulty been got around?

A. The difficulty has been got around in a great many cases by adding a non-frothing oil, so-called, which is adsorbed very strongly by the mineral and which consequently has very marked flotation power.

Q. 95. What about carrying oils, so-called?

A. The non-frothing oils which are adsorbed very strongly by the mineral are usually termed "carrying oils" because they hold up the minerals. They do not in themselves make so much froth.

Q. 96. Which will be washed out of the mineral more readily, the carrying oil or the frothing oil.

A. Since the carrying oil is adsorbed more strongly by mineral than is the frothing oil, when you use a mixture, the frothing oil will necessarily be washed out of the mineral if you treat it with water more rapidly than will the carrying oil. If the brothing oil were adsorbed more strongly than the carrying oil there would be no point in adding the carrying oil.

Q. 97. Is this true experimentally?

A. I have no direct, personal knowledge on the subject, but I am told that that is the case. I have been told it personally and I have

read it in various places; but I have never made any experiment on the point myself.

Q. 98. What would be the effect of treating a frothing oil with a large quantity of water?

3174 A. That would depend a little on whether the frothing oil were a pure oil or whether it was an oil having soluble or somewhat soluble contents. If you wash a pure frothing oil with water repeatedly you dissolve a certain portion of it, anything up to one hundred per cent. As an illustration you might cut it to ninety per cent or eighty per cent or seventy per cent or sixty per cent, depending on how long you washed, but the oil that is left will of course be identical in kind with the original oil, although less in quantity, and will consequently have the same frothing power. If, on the other hand, you have an oil which contains soluble or partially soluble contents then if you wash you will wash out these contents and you will be left with the so-called insoluble content of the oil and you will have passed from a frothing oil to one which approximates more or less closely, depending on the degree of washing to a non-frothing oil.

Q. 99. What is the theoretical relation between the amount of oil and the amount of the ore?

A. If you had the ideal state of things where you got one hundred per cent recovery and one hundred per cent of concentrate it is quite evident, if everything else is kept the same, the quality of the froth and the quantity of the froth will depend solely on the ratio of oil to mineral. That is because under these circumstances the gangue is merely an inert substance at the bottom of your vessel.

Q. 100. What would be the effect of gangue?

3175 A. Of course in so far as any gangue is carried up into the mineral, that is going to change things. In so far as any mineral is carried down by the gangue, that is going to change things, and so far as the gangue carries down some oil, apart from the oil that goes down with the mineral,, which may be the case, that will also change things so that the relation may easily be obscured, somewhat.

Q. 101. Is it necessary always to use the same per cent of oil to mineral?

A. No, that is not necessary at all because of the fact you can stabilize the froth with varying amounts of mineral. That is—of course you get froth of a slightly different character but over quite a wide range of oil to mineral, you will get a pretty nearly stable froth and consequently it is not necessary to keep the ratio of oil to the mineral absolutely constant; and I imagine that is one reason why people have overlooked the fundamental importance of the ratio of oil to mineral. It is a very natural thing to do.

Q. 102. Within your information is there anything in mill practice, any evidences in mill practice that the ratio of oil to mineral is an important thing?

A. I have no personal knowledge of the mill practice, but in Mr. Wickes' testimony the other day it appeared that it was the practice to increase the amount of oil somewhat when the tenor of the head-

ings run out. And other people have told me that that is a general practice. It looks a little as though the mill practice were distinctly in advance of the patents in suit.

3176 Q. 103. Have you made any experiments yourself on that point?

A. Nothing very accurately. I made one rather crude experiment merely to satisfy myself how much variation there was likely to be. To fifteen hundred cubic centimeters of tap water at 50° —there or thereabouts—there were added 300 gms. tailings which I am told contained about one per cent mineral, which would make, in other words, about 3 gms. of mineral in 300 gms. of tailings. There were also added 1 cc. sulphuric acid and 1 cc. pine oil. In the second experiment the mixture contained 1,500 cc. tap water, 5 gms. of what I was told was 65% concentrate containing roughly about 3.3 gms. mineral, very nearly the same as in the other case, 10% difference if you take the tailings as being absolutely 65, which I assume is not important, one cubic centimeter sulphuric acid and 1 cc. of pine oil. Under these conditions you have the same amount of water, the same amount of acid, the same amount of pine oil and approximately, within the limits of the analyses given me, the same amount of mineral; but in one case you have got a great deal more gangue than in the other. And now when these were stirred, it did not come out quite the way I hoped it would—there was distinctly more mineral in the froth, judged by the eye, in the second case where I was using the concentrate than in the first because of the larger amount of gangue, carrying down some mineral, so that it is only an approximate experiment and a crude comparison, but it is really surprising to

3177 see how nearly alike the two froths were when we consider that the percentage of oil to ore was about .62 in the one case—I think that is probably figured on a specific gravity of .9—it is of no importance anyway—and about 18.6 in the other. That is the ratio of oil to ore was something like thirty times as great in the one case as in the other, but the ratio of oil to mineral was practically the same. And, while the froths were not identical, they were very similar indeed.

Q. 104. You used the word mineral, meaning metalliferous mineral all along?

A. Meaning metalliferous sulphide; I assume that that was the correct technical term. I would be very glad to change it if it is not.

Q. 105. What would be the variations in the dilution of the pulp?

A. If you have a soluble frothing oil present in the oil mixture that you are using, having more water in the pulp will of course give you a more dilute solution, and will consequently affect the frothing power; it would be more or less equivalent to using less of your frothing oil; consequently one would expect to find that in any given case, if you keep everything else constant and increase the amount of water in the pulp, you would have to add more oil.

Q. 106. Have you any information as to mill practice that would serve to confirm that conclusion?

A. That part was brought out in Mr. Wickes' testimony, that when the amount of oil in the pulp was increased—I prefer

not to say diluted, because there seems to be some difference of opinion about that; some people say that the dilution increases when you have more water and some people say that the dilution increases when you have less water—so I prefer to say that in Mr. Wicks' testimony it seemed to appear from his data that more oil was needed when the pulp contained more water. I have been told since then that that is the opinion among many of the mill men. I have no personal knowledge of it, beyond hearsay evidence of this sort.

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Q. 107. Under what conditions would these relations occur, strictly?

A. These relations, as I said, would hold strictly for the case of 100% recovery of a 100% concentrate.

Q. 108. But such a state of things is not realized, is it?

A. As far as I know, such a state of things is not realized either in mill practice or in the laboratory.

Q. 109. What are the disturbing conditions?

A. There are a good many things that make trouble there. If the froth is too stiff, of course there will be a tendency of the gangue to become entrapped in it. If the gangue is very finely divided, it will settle more slowly, and consequently the tendency of it to be entrapped will be greater. On the other hand there will also, of course, be a tendency for the mineral to be carried down by the gangue, either because it is entrapped or it may be because when bubbles coated with mineral come in contact with gangue during the agitation, some of the mineral will be rubbed off mechanically, and consequently will be in the same state as it would have been if it had never been attached to a bubble. And further, of course, the stiffer the pulp, that is, the less water in the pulp, the greater the danger of the mineral being carried down. Of course the actual effect of those things will vary in each particular case, with the nature of the ore, the nature of the gangue, the nature of the oil used, the temperature, the question of what you add in the way of sulphuric acid or copper sulphate, and with the nature of the stirring; so that it is probably a very complicated problem. But by keeping everything as nearly constant as possible, temperature, sulphuric acid, nature of ore and nature of oil and degree and manner of aeration, so that your only variables—your things that change—are the concentration of the pulp and the amount of oil and therefore the change in quantity—then I think that there would be no difficulty in verifying all these conclusions from mill practice.

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Q. 110. Will the use of moderate amounts of oil give better results than the use of a minimum amount?

A. Why, it seems to me that it should, because, if you did not have too stiff a froth, you will get more chances for the gangue to settle, and of course also if you get your oil bubbles overloaded with mineral, again there will be danger, so that I would imagine that you would not get the best results in case one worked down to the minimum possible amounts of oil. As I said, I have no personal knowledge of that, but I suppose—I haven't the slightest doubt but that mill practice will confirm that statement.

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Q. 111. What will happen if a single particle consists both of mineral and gangue?

A. Of course if you have a single particle that has mineral on one side and gangue on the other, no amount of flotation will separate those two; it will either go up into the froth or down into the gangue, depending on the relative amounts of mineral and gangue in the particle; and the only remedy I see for that is more efficient grinding.

Q. 112. Up to this point you have a theory which covers the whole ground to your satisfaction?

A. It seems to me that the theory which I have stated enables us not only to describe all the facts that are known, but to predict a number of facts which were not known before.

Q. 113. What type of froth is produced by these conditions?

A. Under all of these conditions as far as stated, you get the same type of froth, one with the cell walls having a film of oil or oil rich solution next to the ore, and the cell walls are stabilized by the presence of the mineral, which makes the films more viscous and therefore more stable.

Q. 114. Is there any change in the type of froth at or about one-half of one per cent. of oil to ore?

A. There is absolutely no change in the type of froth at any such point.

3181 Q. 115. On what does this hypothesis of the critical point rest?

A. Well, that is a bit of an unkind question, but it seems to me that the hypothesis of a critical point rests on unverified and unverifiable statements.

Q. 116. Does the Cattermole phenomenon occur at any definite ratio of oil to mineral or oil to ore?

A. No, the Cattermole phenomenon does not occur at any definite ratio of oil to mineral or oil to ore. The Cattermole phenomenon, which is the granulation of the particles into minute lumps imbedded in oil, will take place at entirely different ratios either of oil to mineral, which is the proper way of putting it, or oil to ore, which is unfortunately the ordinary way of putting it, depending on the degree and manner of agitation; that is, it can be run so that you will get granulation when you have got relatively small amounts of oil, and it can be run with the same oil and the same ore, yet the granulation does not take place at those ratios. In other words, the important factor in there is not the ratio of oil to mineral, or the ratio of oil to air; it is the degree and manner of agitation.

Q. 117. Now, Professor Bancroft, will you summarize for the court your conclusions, with such references as are necessary to the illustrative experiments you have presented?

A. The question to be decided was first as to the type of froth that we have in the case of flotation and, secondly, whether this froth changed in type at any given ratio of oil to ore which,

3182 as I have said, is a bad way of putting things because it does not represent facts, or of any ratio of oil to mineral. Consequently I began back with the simple question of oil and water, using oil again in the broad sense to denote an insoluble oil, so-called,

a soluble frothing oil, so-called, or a soluble frothing agent, so-called. In all these cases we get the formation of a surface film at the interface between water and air which is more viscous than the mass of the liquid and consequently when beaten up with air, such a liquid foams or froths; and it does it under all conditions; and it foams and froths only, so far as we know, when the surface film is more viscous than the mass of the liquid. And to illustrate that we did the experiment with alcohol and water showing why certain concentrations do foam and certain other concentrations do not foam. In the case where they do not foam the surface film is not so viscous as the mass or the bulk of the liquids. Then the question comes up as to the type of froth that you get when you have oil and water alone. Since we know that the oils absorb air more strongly than water does, we know that under these circumstances and with all ratios of oil to water with which we are working we get the same type of froth in which you have bubbles of air, since we are working with air. The films constituting the walls of the froth are either an oil layer, if you are using enough oil to give you a separate layer, or an oil-rich solution in contact with air. Now, go further
3183 into the film and you will get water containing less oil than in the surface film, and that part of it would be less viscous. Consequently we have the same type of froth throughout when water—when we have oil and water alone. And, as I said, so far as I know, that is not disputed as yet by anybody. Then these froths are—at least the froths that I was considering—are all more or less evanescent. That is, they break down very quickly; some of them break down extraordinarily quickly. If we make these films more viscous in any way we shall stabilize these froths and get froths of varying degrees of permanency, depending on the viscosity that we produce under these conditions. Now that can be done by means of a very viscous oil, and I cited the case of the oil mixture of the Butte & Superior Company where they have a relatively large amount, 70% of fuel oil, which I understand is a very viscous oil. And that does give, because I know personally, a more or less permanent froth without any other stabilization. On the other hand, you can stabilize the film by introducing into it a solid which will stay there because the presence of the solid in there increases the viscosity just as increasing the amount of ore in a pulp would increase the viscosity of the pulp. Then of course the next question is what substance will go into that film and will stay there? Any substance, any solid which is adsorbed strongly by the oil layer, by the oil-water interface or by the oil-rich solution, will pass into that part
3184 of the film—The question of stabilization by means of a solid under these circumstances is absolutely independent of the chemical nature and origin of the solid except insofar as the chemical nature determines whether the substance will go into the film or not. That is, you may have the case where the mineral goes in and the sand does not. If you find a hypothetical oil which may exist, although I do not know of it, which adsorbs sand or gangue very strongly, then you could stabilize your film with sand or gangue. There would be no profit in it, but it could be done. Instead of

hunting for that hypothetical oil, which would probably take a good while, it seemed to me it was simpler to take a number of different solids which could be made to stabilize certain froths and to show that under these conditions the chemical nature of the solid had absolutely nothing to do with the problem, and that the whole question was whether you had a solid which did go into the surface of the film. In order to show that I have taken—of course everybody knows it in regard to mineral—I have taken among others lycopodium powder, which is a vegetable product. As I said, it is the spore either of a moss or a fern, I don't know which—but I have taken white lead, which so far as I know does not occur as a mineral anywhere, and certainly the white lead that we used did not occur as a mineral, and I have taken lamp black, which is a different
3185 substance. The only reason for taking those things is that I think that I have read somewhere, although I cannot lay my finger on the reference, that somebody or other said that only those substances floated which were metals or were like metals; that is, in other words graphite, which conducts electricity metallically, and the crystallized sulphides which do look like metals—which have a distinct metallic luster. In fact I think in that same paragraph which I am certain I saw but I cannot find it although I looked for it, there was also a statement that they believed that precipitated zinc sulphide would not float because it was not crystalline and metallic. So, it seemed to be very desirable to try the experiment with substances which did not resemble metals in any respect; and I cannot see any way in which anybody could claim lycopodium powder or white lead as being similar, either in properties or origin to a metal. Personally I would not want to classify lamp black either under either head although of course it is carbon, one form of carbon, and graphite is another form of carbon. If anybody insisted that this was an immaterial point I would be willing to meet him half way on that although I should still think he was wrong. I have shown that under these conditions these things go into the film; further it is not a property of the particular substance in itself since we have selective adsorption. Mineral goes into an oil in preference to gangue. Consequently in the same way when we start with
3186 different soluble frothing agents or oils we may get selective adsorption so that a substance which will stabilize one froth will not stabilize another. The lycopodium powder stabilized the pine oil, which is a soluble frothing oil, so-called and it stabilized the alcohol, which is certainly a soluble frothing agent; on the other hand lycopodium powder had no stabilizing effect whatever on acetic acid. That is, in other words, you are getting a selective adsorption; the lycopodium does adsorb alcohol and does adsorb pine oil to a sufficient extent to enable it to stabilize the froth, while lycopodium does not adsorb acetic acid in sufficient extent to give us a stable froth. In other words, the whole thing is selective but it is not, however, a peculiarity to acetic acid, that you cannot stabilize it. We know that we can stabilize an acetic acid froth by means of mineral and I showed that we could stabilize acetic acid by means of lamp black and I further showed that we could stabilize phenol by

means of lamp black; that on the other hand, we could not stabilize phenol by means of white lead. I did not try white lead with acetic acid because the probabilities are that the acetic acid would react with the white lead. Now, I could have gone on, if I had had unlimited time and so had everybody else, and have worked up an indefinite number of other substances that would work exactly the same way; but it seems to me that lycopodium, white lead, lamp black and mineral are sufficiently definite to establish the
3187 principle that the nature of the solid is of no account, so long as it is adsorbed. Now, since the only function of the solid, from the theoretical point of view, is to stabilize the froth, and since it is the solid which is adsorbed in the surface of the film which stabilizes the froth, there can, therefore, be no change of type in the froth; and since the froth, in the absence of the solid, is all of the same type, that is with an oil layer or an oil-rich solution next to the air, it is still of the same type when you add the solid and there is not any possible way, so far as I can see, that the solid should cause that froth to turn inside out or to do any other laboratory tricks, and consequently we come to the theoretical conclusion that the type of froth does not change with varying the amounts of oil in there and that is confirmed by the experimental fact that when you make a froth under the different conditions as shown in the experiment with the three jars on the edge of the desk, you cannot possibly recognize any difference in type in these three froths, although one of them contained in round numbers 0.29 per cent of oil to ore; one contained .087 of oil to ore in round numbers, and one contained 1.45 per cent of oil to ore, also in round numbers. Further, then, the whole nomenclature seems to me rather footless, if you will permit me to use that word; that is, people talk about "the ratio of oil to ore." Now, except so far as the gangue goes up into the froth or the mineral goes down into the gangue, it is perfectly clear that the important
thing in any particular case is the ratio of oil to mineral and
3188 not the ratio of oil to ore; and that, so far as one can see, is also confirmed to some extent by mill practice where the operator is judging by eye the looks of the froth—perhaps I ought not to say that he is judging by the eye because I do not know that definitely—but anyhow it seems to be the practice that when the amount of mineral in the ore goes up, they add more oil. And of course I admit that there is a certain picturesqueness about expressing things in the ratio of oil to ore. That is if you take about one tenth of one per cent of oil to ore it apparently appeals to one's imagination that that is a very remarkable, striking thing, and a very low amount of oil in reference to the ore, which is true. On the other hand, if you figure that around as it should be figured in the case of the ore containing seventeen per cent mineral your ratio of oil to mineral is approximately six per cent, allowing for errors in multiplication and division, which is not half as impressive. If you go down further to the case of an ore containing four per cent mineral why, this same thing figures out 25% of oil to mineral, which is—well, that is beginning to be interesting again but on the other side. I cannot see any possible scientific justification for refer-

ring the amount of oil to the amount of ore because the important factor in there is the ratio of oil to mineral and it does not seem to me that mere picturesqueness is important, under the circumstances. On the other hand, I am quite willing to concede that this is a point on which people can very easily be misled because you can
3189 stabilize a given froth fairly satisfactorily with varying amounts of mineral and consequently it is possible to work with a given oil and a given ore and vary the ratio of oil to mineral over quite a range without necessarily getting bad results; and I think that that is possibly the reason why people have gone to pieces in this case and have laid stress on the ratio of oil to ore when they really meant the ratio of oil to mineral.

As I said, of course you get that most clearly in the unrealizable case where you have 100% recovery and concentrates, which, as far as I know, never occurs. You will get distributing forces so that, when the froth is stiff, it will naturally entrap more of the gangue, and consequently give you a lower grade concentrate. When the gangue is very finely divided and consequently settles very slowly, that also will be a factor giving you a higher amount of gangue in the froth; on the other hand, when your gangue settles very rapidly, it is likely to carry down a certain amount of mineral with it. That mineral may be either entrapped mechanically, or it may be that you get an actual mechanical rubbing off of the mineral from the films of some of the bubbles. In fact in some of the photographs that comes in as far as I know here are some of the questions in conbles had come in contact with the face of the glass, that the mineral was entirely gone from them, and you got a shining film, the mineral being off at the side of the bubble. Now, the only other thing that comes in as far as I know here are some of the questions in con-
nection with the feed. I have already stated that it seems to
3190 be mill practice to increase the amount of oil when the mineral content of the headings runs up. When the amount of water in the pulp runs up, we have two factors coming in, the factor pointed out by Mr. Taggart, that we have a higher concentration of the mineral particles and consequently a greater possibility that they will not all become entrapped in the bubbles, and you have also the possibility that you dissolve out more of your frothing oil from your oil mixture that you are using, in case you are using an oil mixture, and that consequently you are working with what is analogous to a different oil. The difference, may not be very great, but it would be real difference. So that those are all factors which come in and disturb the situation. Then, of course, you also have the possibility of varying the nature and kind of the agitation, either by using a different machine, by stirring more rapidly, or by feeding in more air, and those things will all have their effect in changing the amount of froth and the equality of the froth; that is, going back simply to the case of oil and water, if you put that in a bottle and shake it by hand, which is a primitive and tiresome method, you can only convert a relatively small amount of oil over into bubbles for the same cross section of the bottle, because we do not shake it violently enough. On the other hand, if you take it

with a more efficient stirrer, then under those conditions you can run up the amount of the oil in proportion to the cross section of the vessel and get a great deal more froth, as has been shown by these things that we have worked here. It would have been
3191 quite impossible for me to have taken one of those glass jars, even if I had a stopper for it, and had shaken the oil and water in that and have produced the amount of froth that we could in the other case. Consequently the kind and nature and amount of the aeration will play a very large factor in determining what ratio of oil to mineral you can use safely, so far as I can see, you can vary the amount of oil to mineral over a very wide range and still get a froth—of course not the same froth, but identical in its properties—by simply changing the absolute amount of air that you pump in in a given time, and the way in which you pump it in. I think that covers pretty nearly all of the points, though not all.

Q. 118. If one has a relatively heavy mineral particle under water and coated with oil, and if an air bubble is brought near it, what will happen?

A. The air bubble will attach itself to the oil and will tend to raise the particle. If the particle is relatively heavy, the oil will neck out—the tensile strength of the oil is not high—and consequently the bubble will not raise the particle, but will pull off a small amount of the oil from the particle, and will go up as an oil bubble. Now, you can go on repeating that, and you will take off a little oil every time, a little more oil, and you will get down to the point where, instead of having a thick film of oil on the bubble with relative little tensile strength, you have a very thin film of oil, which under those conditions is both more viscous than the mass of
3192 the oil, and also of greater actual tensile strength, and then you will come nearer and nearer to lifting your particle. If that particle is large enough you cannot lift it under any circumstances; if it is of a medium size you will reach a point, by the removal of the oil, where you will be able to lift it. The smaller the particle is, the easier it will be to lift and the less oil it will be necessary to remove from it; so that, with a very small particle you can lift it and should be able to lift it even if it were oiled pretty thoroughly heavily, and with a larger particle you would have to get down to a relatively thin film of oil before you could succeed in lifting the particle.

Q. 119. When an air bubble meets an oil globule without violent agitation, what will happen?

A. Again the air bubble will tend to pick up the oil globule, and the oil, or some of the oil will pass around in the interface between water and air, just exactly as it does when you put oil down on a flat surface of water in a beaker in contact with air, and just exactly as was shown in one of the diagrams this morning by Prof. Beach. Now, the oil, of course, barring the influence of gravity, would tend to concentrate uniformly in a film around the air; under the influence of gravity, of course it could not be quite uniform; in fact it distinctly will not be uniform, and you will get more of the oil down at the lower end of the bubble; and since the thick film of

oil—I am using thick without giving any definite limit to the size for a moment—is not stable, and consequently the oil will pull off, and you will have your air bubble with a thin film of oil
3193 around it, and the rest of your globule of oil will be drifting around wherever fate may take it; it depends on the arrangement of your apparatus.

Q. 120. Would it seem likely to you that these things you have stated might cause one to conclude that the air bubbles do not directly attach themselves to the oil globules, and have slight, if any lifting power?

A. Why, if a man were just simply doing the thing, without knowing very much what he was doing or without having any special theory either to guide him or hinder him, as the case might be, I think it would be a perfectly natural mistake for a man to make, and I would expect a man who observed those things and did not analyze them carefully, to draw exactly that conclusion. The conclusion would be wrong, however, in spite of its being a plausible one.

Q. 121. Does it seem probable that one might draw a conclusion that air bubbles do not attach themselves to metallic particles coated with sufficient oil to produce adhesion?

A. If you were working with a sufficiently large particle, that would be the natural conclusion to draw from the experimental evidence if you did not analyze it. It would be an inaccurate conclusion, for the simple reason that it is not so.

Q. 122. What would be the more accurate way of putting it?

A. Why, I should prefer to draw the conclusion under
3194 those conditions, that the cohesion between oil and oil was less than the adhesion between oil and air, and that consequently when you put the strain on it, the break comes in the oil, and the bubble carries off a small amount of oil with it; which is exactly what it does experimentally.

Q. 123. Can you give any illustration of a similar nature from some other field?

A. Yes. If you take a solution of gelatine or glue in water—and of course glue is simply impure gelatine—and put it in a glass beaker and let it dry, it dries down to an apparently solid mass. If you allow that to dry still further by putting it in a very dry atmosphere, the adhesion of the gelatine to the glass is so strong, that even though you have got a smooth bottom in your beaker on the inside, that gelatine holds on to that so strongly that when you take it off it pulls pieces of glass off of that surface. The experiment does not always succeed, because sometimes it breaks the beaker all to pieces, simply doing it a little more; but when you get the thing going, where you get it finally with a gelatine film that has torn pieces of glass right out of that surface—you can conceive what force it would take to break little pieces of glass off the smooth surface of the window pane with your fingers—it gives one a realization of the force that may be acting in the case of a surface film where you have two different substances. Of course I do not mean to say that your oil film could, under any circumstances pull pieces out of the mineral

particle, even though the mineral particle were large; but it
3195 does bring out this other point.

We have another instance of much the same thing in a glue joint. If you glue two pieces of wood together in a careless way with a pretty thick glue joint in there, then under those circumstances the strength of one part of the glue to the other does not amount to very much, and the thing will break at the joint every time. If you do that thing in an honest, workmanlike manner, with your glue warm, so that it goes into the wood a little, and do it with as little glue as you can, and press practically all of the glue that there is there out, so that you have the merest thin film of glue between the faces of the two pieces of wood, then you will get a joint, which, when it breaks, will usually break somewhere else. Of course if the thing which you were to glue were two trees, butt to butt, I imagine under those conditions probably if they broke that they would break at the glue joint; but under ordinary conditions that arise in cabinet making for instance, a first class glue joint is stronger than the wood. That is not a question of mill practice; that is actually experience.

Q. 124. If air bubbles are produced in pure water, would you expect them to be large or small?

A. I am assuming that you are having your bubble produced from a tube or some other orifice. The size of the bubble produced under those conditions depends on two things; first, the size of the opening, secondly the surface tension of the liquid in which
3196 the bubble is produced. If you stick to the same sized orifice, you would get a larger bubble the higher the surface tension of the liquid, and as you are dealing in this particular case with water, you would get relatively large bubbles. Of course that does not mean that if you worked with an infinitely small orifice the bubbles will be as large as a balloon, but they will be much larger than they would be if you worked in another liquid which had a lower surface tension, because those two things, the size of the orifice and the surface tension of the liquid are the two forces which determine the size to which the bubble may grow before it tears loose.

Q. 125. If anything were added to the water which reduced its surface tension, would you expect the bubbles to become larger or smaller?

A. They would of course become smaller, because that is one of the very nice and satisfactory methods of determining the relative surface tensions; that is, you take a glass tube of a given size, and you let air bubbles out of that into different liquids, and you will get the largest bubbles in the liquid, as I have just said, with the highest surface tension, and in the liquid with a lower surface tension you get smaller bubbles, or with the same liquid if you have added something to it which lowers the surface tension, you will get smaller bubbles, and that is the—is one of the recognized ways—one of the easy ways of getting a qualitative test of the relative surface tensions.

You may also go at it around the other way, of course, by
3197 letting the liquid run out of the orifice. For instance, let the liquid run out of the burette either into the air or into another liquid, depending on what you want to study. If your liquid

has a high surface tension your drop will grow to a relatively large size before it breaks off from the burette. If it has a low surface tension you will get a much smaller drop, or if you take a liquid and do anything to it, add soap or saponin or salt or something of that sort, your drop will be larger or smaller depending on whether the surface tension is increased or decreased, and in that way the thing can be used as a quantitative method of determining the surface tension, that is, you weigh the number of drops, or a given amount of the liquid, and work back from that to the surface tension. Under ordinary conditions that is not very accurate, because the theory calls for a drop which breaks off cleanly and leaves nothing behind, but if you run a burette or anything of that kind, we know that under ordinary conditions you get a drop coming off, not clean; there is a small drop left behind. It has been shown by Morgan of Columbia that if you use—I don't know the exact conditions, but if you use a tube with a bevelled end, instead of a tube that simply comes down square, under those conditions a clean drop is removed, and he has used that as a quantitative method of determining relative surface tensions of different liquids and different solutions. So that, of course, you would get a smaller bubble in case you added anything to the water which lowered the surface tension, and con-
3198 versely you would get larger bubbles if you added anything to the water which increased the surface tension. That is first principles.

Q. 126. Do oleic acid, phenol, cresol and amylacetate lower the surface tension of water?

A. They do.

Q. 127. If bubbles generated from small orifices—in solutions of these substances, might we get an effect which could be described as smoke?

A. I see no reason why you should not. If we have a very fine orifice the bubbles in themselves will be small; and if we add to the water anything which reduces the surface tension, your bubbles will be smaller still, and consequently it is merely a question of how small your orifices are what your definition of smoke is, whether you would call the thing a smoke or not, but I can not see any reason why you should not get a cloudiness in there which could perfectly legitimately be called smoke. I never tried the experiment, but it sounds perfectly reasonable.

Q. 128. What can you say about the liquid film in contact with the air of the bubble?

A. Well, I have been trying to say that a great many times all day, that in all these cases you have either an oil layer or an oil-rich layer next the air, and that—if you do not want to use the word "oil"—if you have phenol in solution, that the film in im-
mediate contact with the air will be higher in phenol than the
3199 mass of the liquid. The same thing will be true of cresol and with amylacetate and with anything else of the same type that may come up.

Q. 129. Do you agree with the proposition that mineral frothing agents are generally not oils or oily in character, so it is a mere inci-

dent that oils are also mineral frothing agents—the word mineral being used to mean metallic sulphides?

A. I should think that was a very misleading statement. In a sense, of course, it is perfectly true; that is, in the narrow sense of the word, you don't call acetic acid an oil; that is, in every day life, acetic acid is not called an oil, and consequently to that extent it is justifiable. On the other hand, the practice in flotation matters is to call everything an oil which tends to show a selective adsorption for mineral as opposed to gangue. Now, that may or may not be a good thing to do, but it is the regular and established practice, and consequently when one is talking about flotation, acetic acid is an oil, and while it is perfectly legitimate anywhere else to say that acetic acid is not an oil—I should not classify acetic acid under ordinary conditions as an oil—it certainly is an oil under the established usage and customs of flotation matters, simply because it is better to call all things by the same name when they behave in the same way. In regard to the selective adsorption of mineral with reference to gangue, you get that with oils, with soluble frothing oils and with so-called mineral frothing agents, as defined by Mr. Williams—they all behave in exactly the same way; in other words, they all show
3200 selective adsorption, and consequently they are all oils, and consequently under that nomenclature acetic acid is an oil and the statement is inaccurate. You can not judge a statement of that kind except with reference to the context, and it is perfectly true under some circumstances and it is absolutely false under others. That is why I prefer to classify that as a misleading statement.

Q. 130. Would you expect that air bubbles disseminated by a suitable agitation in the presence of a soluble frothing agent, would search out mineral particles from the ore pulp, pick them up and carry them to the surface, leaving the gangue?

A. I don't see how they could be expected to do anything else, because by your definition of a soluble frothing agent, it is going to have a selective action, and that seems to me simply—I may not have understood your question, but it seems to me like saying the thing right over and over again.

Q. 131. In these cases are the air bubbles in direct contact with the mineral particles?

A. Again that is the same question; they are not. Under those conditions you have—you might say—an oil layer—the oil layer you have is different, because it does not come out as an oil—you have a relatively oil rich solution in contact with the air throughout, and you do not have any contact between the solid particle and the air under these circumstances.

Q. 132. Is it possible to have direct attachment of your air bubble to a mineral particle?

A. Theoretically I think it is; that is, we know that in
3201 the case of so called minerals, zinc sulphide and lead sulphide, they do generally adsorb air markedly. The reason we know that is because they are not wetted readily by water, and since the air is adsorbed markedly, there is no reason why you should not have

direct contact between the sulphide and the air, and there is no reason why under suitable conditions you may not have an air bubble in contact with the mineral and actually lifting it. On the other hand, you may not have that, if you have present in your water either an oil—either an insoluble oil or a frothing oil or a soluble frothing agent. In other words, the thing is perfectly possible theoretically; I should not think of disputing it. Whether it occurs in any given case or not is a matter to be decided with reference to that particular case.

Q. 133. When mineral particles are apparently lifted by the air, is it certain that that is really happening?

A. No, I don't think it is, because there is always a possibility that the mineral particles are not clean in the beginning; that they may have had on their surface either oil or greasy matter from somewhere, and that consequently under those conditions one was not dealing with the direct contact of air with mineral. That would all depend, as far as I can see, on the degree of care with which the experiment was carried out, and I should not be willing to accept the mere statement that one had a contact between air and mineral as conclusive unless the thing were shown to be so. It is perfectly possible
3202 that you may have it, but it is equally possible that experimental errors may come in. Even I can not do my experiments and make them come out right every time.

Q. 134. Have you any independent evidence to confirm your statement on this subject?

A. Yes. If you take a piece of mica and split it into two pieces or two plates; now, if you press those pieces together any time within three or four minutes, the thing will go back and make practically one piece of mica instead of two. If, on the other hand, you wait more than three or four minutes—say if you wait ten or twelve minutes, then you can not possibly press those two pieces of mica together and make them weld into one by any pressure that any ordinary man can exert with his thumb and forefinger; which shows that during the ten minutes that those fresh mica surfaces had stood exposed to the air, that something—a film of air or a film of water or a film of grease had condensed upon them, so that when you press them together you do not really bring the things into intimate contact.

Now, there is another rather interesting thing about that. Lord Rayleigh states that the film which forms first on the surface of the mica conducts electricity, and therefore he concludes that it contains water; that is, in other words, that it is chiefly or partly moisture condensed from the air; that in the course of a few hours—I don't know how many—but in the course of a few hours, instead of having a conducting film on the surface of the mica which conducts
3203 electricity, you get a non-conducting film, from which he draws the conclusion that it is due to adsorption on the surface of the mica of grease or oily matters from the air.

Now, of course in view of that thing which we know in the case of mica and which can be determined experimentally and has been determined experimentally, it seems to me very doubtful whether any particle of mineral which has been exposed to the air, unless

extraordinary precautions have been taken, should be free from grease or oily matter, and for that reason it seems to me very doubtful whether anybody has ever shown the actual lifting of a mineral particle by direct contact with air, although I am perfectly willing to admit the theoretical possibility. In fact, I would go further, and say that theoretically it is unquestionably possible, but one would have to consider in any particular case whether the man who did the experiment had taken enough precautions to prevent the contamination of the surface, which would certainly take place very readily if the particle was exposed to air.

Q. 135. Do you know of anyone ever having performed any such experiment, taking the precaution which you have described to avoid contamination of the particle?

A. I don't know of any experiments that have been performed where the necessary precautions have been taken.

Q. 136. Is it true, then, to say that in the agitation froth process, the froth, and the single bubbles, therefore, consist of metallic
3204 particles held to air bubbles by direct attachment?

A. It is not true. In all those cases you have an oil layer or an oil rich solution in contact with the air, and the particles are in the oil film or at the oil-water interface, or in the oil rich solution, depending on which particular case you are studying. I do not see any possibility under any circumstances where you can have direct connection between air and a particle in the presence of any of these so called frothing agents, and I do not believe it occurs.

Q. 137. Do you consider the proposition correct or incorrect that the fundamental principles of flotation are air entrainment and the increased affinity of air for metallic particles in the presence of a frothing agent?

A. It is perfectly right to say "air entrainment" if one knew what it meant. If you mean that an important thing in flotation is the formation of bubbles containing air, that part of the statement is true. The other part of the statement, that an important factor in flotation is due to the increased affinity——

Q. 138. The increased affinity of air for metallic particles in the presence of a frothing agent?

A. The statement that the "increased affinity of air for metallic particles in the presence of frothing agents" is an important fact in the flotation process seems to me absolutely and hopelessly wrong because, as I say, you never do get, under these circumstances any contact between the air and the particle. If you did, it
3205 would be a very important and a very interesting thing, but you don't do it.

Q. 138½. If you were told that when a bubble lifting metallic—if you were told that when air bubbles lifting metallic particles, met the thinnest possible oil layer they dropped the particles, how would you account for it?

A. Well, I would account for it, I think in two ways: in the first place, I should account for it by saying that if the bubble hadn't any viscous film it would of course burst and the particle would be dropped back into the oil where it would either be held up by the

bulk oil process, or it would not, just as the case might be. That would depend on the size of the particle. The other way of accounting for it, which seems to me to be simpler, is to say that I know that it is not so because I have seen a particle lifted up with an air bubble in a bubble holder through an oil film. I admit it is not an easy thing to do experimentally, and one might easily fail twice in three, but I have seen the particle come up. So that under this condition I don't quite see why I should be expected to account for its not coming up.

Q. 139. What would you call a froth made by agitation at about 1,800 revolutions per minute, 80 cc. of water at 70°, 16 gms. Broken Hill tailings, .6 cc. 20% sulphuric acid and one drop of oleïc acid, which would be between one tenth and two tenths of a per cent on the ore?

A. Well, I would much rather have that put in terms of oleic acid to mineral, because, as I have tried to point out, that is the
3206 only rational way of doing it; but of course that hasn't any bearing on the experiment. I should say there can be absolutely no question but that that would give you exactly the same type of froth that we have been discussing ever since we came here; that is a froth in which you have an oil layer or an oil-rich solution in contact with the air.

Q. 140. In your judgment would it be proper to call such a froth an air froth, meaning thereby that the air is attached directly to the mineral particles?

A. It would not be proper to call it that because that is not what happens; and it is a great deal better, it seems to me, to stick to facts.

Q. 141. Is it possible to obtain a so-called oil froth in which there are oil globules, with the mineral distributed entirely through the globules, with skins of dividing water partitions between the oil globules and with particles of air entrained between the globules?

A. I don't see any difficulty about doing that. Suppose you were to take the bulk oil process and shake up the oil until you get some of the oil down in the bottom of the beaker, let us say, if we are doing it in a beaker, as oil globules. Now, these globules might or might not contain particles of mineral—it could perfectly well be arranged so they would, I imagine, so that all of these would. Down there, you have all globules containing mineral particles inside of them, separated by either thick layers of water, if you only had one or two globules, or by thin layers—which you could call films, in case you had a great many down under this condition. Now, I see no
3207 difficulty whatever in blowing in air,—I don't know that you could do it—I never tried it, but I don't see any inherent reason why you should not blow in a small amount of air, avoiding marked agitation, so that the air bubbles would cling to the oil and you would then have an oil globule containing mineral separated by watery films and containing air—did you say "entrained" or "entangled"—whichever it was, between them. Now, that is starting with a lot of oil. Of course, if you start with small particles, either a single particle with a little oil around it, or if one performed with a granulated particle, Cattermole effect, with oil around that, under

this condition—under these conditions your granules would have particles with oil around them and no air. And now if you had enough of that and the ratio of solid to oil was not too high and if you got air entangled in them in the same or similar way, I see no reason why they might not float up to the top and give you, on the surface, oil globules with particles of mineral entirely inside the oil, with water films separating the globules and with air bubbles scattered around more or less frequently through the oil. I don't know whether I can do the thing experimentally, but it seems to me—that is I don't know it from my own personal knowledge—but I do not see any conceivable reason why it should not be done if anybody wanted to do it. I think I can do it myself if I had to.

Q. 142. Well, would such a so-called oil froth be identical with the froth obtained in the agitation froth process?

3208 A. Why, no, of course not—absolutely not, different in every respect.

Q. 143. Is this so-called oil froth that you just described in one of the previous questions a true froth?

A. No, it is not a true froth at all, because it does not come under the definition as given. Of course every man has a right to make his own definition, but afterwards he has got to live up to it; and the definition that I made which I think is the definition that would be accepted by pretty nearly everybody—probably with slight changes in wording—I don't care about that—is that a froth is a closely packed mass of bubbles having a honey-combed structure with the cell walls composed of liquid films and the individual cells filled with air or other gas. Now, if anybody is going to be hypercritical I will modify that. Of course when I say, "honey-combed structure" I mean what anyone would under ordinary conditions. I do not mean that a cross section of one of those bubbles is actually hexagonal in shape as is the case of a honey-comb of a bee, but I am using the word "honeycomb" in the ordinary way in which the word is used.

Cross-examination.

By Mr. Williams:

X Q. 144. Professor, you mentioned an article as having first attracted your attention to flotation, Swinburne's article?

A. I did.

3209 X Q. 145. And I thought you had the article at the time?

A. I did.

X Q. 146. May I look at it?

A. Certainly, with great pleasure. I supposed you had seen it.

X Q. 147. The discussion in this article is of the so-called Potter-Delprat process, is it not?

A. I think that is what it is. I so understood it, although he carefully avoids putting it in that way. That is my recollection of the article, that he says he is going to discuss it from a purely scientific point of view without any reference to any definite—or without

any specific reference to any definite process. As a matter of fact, however, I think your statement is perfectly correct.

X Q. 148. I understood you to say during your testimony that Dr. Adolf Liebmann had said that a phenol when present in water in such proportion that it was not dissolved was an oil? Where did you take that statement from?

A. I did not make that statement in exactly that form. As I understood you, you read it that I said that "a phenol." My statement was that phenol—of course it comes to the same thing, but there are a number of substances which are phenols. I can give you that reference in a moment or two. I think I have it in my notes. You will find it in the third volume of the Miami transcript, page 1852. I think I quoted it correctly. I vertified the quotation.

3210 Mr. Williams: If your honor pleases, I would prefer to read over the deposition of Professor Bancroft before the cross-examination, thereby hoping to save considerable time.

The Court: That hope springs eternal. Well, it is five minutes of five and we will adjourn until 10.00 o'clock tomorrow morning.

Whereupon an adjournment was taken until Saturday, April 28th, 1917, at 10.00 a. m.

Saturday, April 28th, 1917—10.00 a. m.

WILDER E. BANCROFT resumed the stand for further

Cross-examination.

By Mr. Williams:

X Q. 149. Reading from your testimony of yesterday, in your answer to Q. 34, you said, "Dr. Adolf Liebmann said that when you add a small amount of phenol, so that it is all dissolved in the water, it is a soluble frothing agent, but if you add an excess of phenol it is an oil, therefore of course would come under the head of partially soluble oils." I have read the part of the testimony of Dr. Liebmann in the Miami suit to which you gave me specific reference as authority for that statement, page 1853, and it seems to me that you have not quite accurately stated what Dr. Liebmann
3211 says; so I will call your attention to Dr. Liebmann's testimony, answer to X Q. 249, and ask you if you wish to correct that statement. (Handing witness copy of testimony.)

A. He says that phenol is a soluble frothing agent, and he says here at the top of the page that an excess of phenol is an oil, and he says, in the answer to question 2051, "I say it is phenol as an oil." I don't see any reason for modifying that statement.

X Q. 150. Well, the differentiation which occurs to me is that his statement is that it "acts as an oil"; I quote those words from his answer to 2049: "as an oil," and wherever he repeats it he always says "as an oil," but that he does not anywhere say that it is an oil.

A. I think he does.

X Q. 151. Do you accept that correction?

A. No, I do not. In 2049 he says, "Now, that excess of phenol over and above the amount that will go into solution, in what condition does that exist? As an insoluble substance as an oil; it exists as an oil." He does not say that it acts as an oil. I don't see any reason for modifying that statement.

X Q. 152. Then I will read the full statement so that we may have a comparison. "X Q. 2049. Now, that excess of phenol over and above the amount that will go into solution, in what condition does that exist? A. As an insoluble substance, as an oil. X Q. 2050. As phenol or as some hydrate that exists there? A. It is an oil. Q. 2051. Does it still exist as free phenol, or does it form some combination with the water? A. I say it is phenol as an oil. Q. 2052. Well, this excess over and above what is in solution is
3212 still simply phenol? A. Yes." I think that covers it?

A. I think it covers it, yes.

X Q. 153. That is the correct reading of the testimony, is it not?

A. Absolutely correct.

X Q. 154. Now, dipping a piece of galena, for example, into a particle of insoluble oil, some oil is removed by withdrawing the galena from the oil, is it not?

A. It is.

X Q. 155. What is the condition of that oil; does it become attached to this metalliferous particle?

A. If you mean—what do you mean by what is the condition? It is oil.

X Q. 156. What holds it to the metal particle?

A. It is absorbed by the metal particle.

X Q. 157. Does it adhere to the metal particle?

A. I should prefer to say that it is absorbed by the metal particle because that is more accurate.

X Q. 158. What is the thickness of the coating that you get around the metal particle in thus dipping it; does it—it gives you what measure of adsorption layer?

A. By adsorption layer do you mean the thickness or the force with which it is held, or what do you mean?

X Q. 159. Well, we will take thickness?

A. The amount of oil that will be on the surface may vary with the conditions of the experiment from a very small amount up to an amount—a thickness which would drip off, depending on the
3213 way in which you hold it. I don't see any way that you could get a thicker layer than the amount that would drip off.

X Q. 160. Would the amount that would not drip off be an adsorption layer?

A. I think you could call it that—that oil would be adsorbed.

X Q. 161. All of it?

A. All of it, I think.

X Q. 162. What is your authority for that statement?

A. I think I would prefer to quote myself as authority for it.

X Q. 163. Is there any other authority?

A. For the existence of adsorption under the conditions that I have stated?

X Q. 164. Yes.

A. I don't remember whether anybody who has written a book on colloid chemistry has discussed the specific case of oil and galena. I can not see why anybody should have taken it up, and I don't remember that they ever did.

X Q. 165. That thickness of the oil layer that would not drip off would vary with the viscosity of the oil, would it not?

A. Yes.

X Q. 166. With a viscous oil, would it still be an adsorption layer?

A. That would depend on how you looked at it. Personally, I should consider that as an absorbed layer because the oil is
3214 adsorbed at the surface between the galena and the oil; and as long as the rest of the oil is there I think it would be less confusing to call it an adsorption layer. If you prefer to put in any other definition I would be glad to discuss it in terms of your definition.

X Q. 167. Do you recognize any difference between adhesion and adsorption, as applied to the terms that I have stated?

A. Yes, adhesion and adsorption are two entirely different things.

X Q. 168. I would like you to define the difference.

A. Adhesion is the holding together of two dissimilar substances, whereas cohesion is the holding together of two parts of the same substance. Adsorption is a surface condensation or concentration as the case may be, and of course involves adhesion, but the two are not identical. That is, you have got to eat to live, but eating is not necessarily living.

X Q. 169. Well, can you point out the difference in the instances that I have given, where a coating of oil adheres to a metallic surface, and, as you put it, a coating of oil is adsorbed on the metallic surface.

A. When it is adsorbed, then of course it adheres, but the two are not the same, although both take place or may take place simultaneously; but as a result of the adsorption that substance adheres to the underlying particle.

X Q. 170. Can it adhere without adsorbing?

A. I do not know, but I think not.

3215 X Q. 171. Now, in the instance of a highly viscous oil, you would get a thicker layer, wouldn't you?

A. You would get a thicker layer, yes.

X Q. 172. It would adhere to the metallic particle?

A. It would.

X Q. 173. And, by reason of its viscosity, a thick, comparatively thick layer, would be obtained; is that right?

A. Yes.

X Q. 174. The adherence would be the result of a force, would it not, molecular force?

A. It would result from the fact of the adsorption. If it were not adsorbed, as I said, I think it would not adhere.

X Q. 175. But it would be the molecular force would it not, or the result of the molecular force?

A. I would prefer not to talk about molecular force, because there

you go off into a realm where you can speculate as much as you like without getting anywhere. I prefer to stick right to the terms that I used, that it is adsorbed. Why it is adsorbed I do not know, but it is a fact that at the surface of any solid or liquid, you tend to get adsorption of a gas, or a liquid or of a solid as the case may be. And, that that adsorption is selective and varies with the nature of the solid, the liquid and the gas.

X Q. 176. Can you give me an exact definition of adsorption?

A. Adsorption is surface condensation or concentration.

3216 The Court:

X Q. 177. Would you say it takes place within the solid, too?

A. You can have an adsorption of a solid by another solid. For instance, for polishing metal we often use rouge in water, and there the rouge acts as an abrasive and polishes the surface of the metal. If, by any accident you let the rouge get dry, you will find that it will adhere very firmly to the surface of the metal and will spoil the polish. You have another case of it, of a similar sort, in impure mercury, where mercury flours. That may be due to the adsorption of grease—perhaps you wouldn't want to call grease a solid—or you may have it with an oxidized film. The case I cited the other day of a dry glue with the glass, the glue could not pull the splinters out of the glass unless it were adsorbed by it. Of course one might say that dried glue is a liquid and not a solid, but in the case of the rouge you have an unquestioned solid.

Mr. Williams:

X Q. 178. In that oil layer whether we have adsorption or an adhesion resulting from an adsorption with a viscous layer or with any layer, there would also be cohesion, would there not?

A. Certainly, between any two thicknesses or portions of the oil you will have cohesion.

X Q. 179. That is between the molecules and the like substances there is cohesion? Am I accurate?

A. I didn't say that, no.

X Q. 180. Well, then, please define cohesion as you would like to define it.

3217 A. Cohesion is the holding together of two parts of a like—of the same substance. I did not say anything about the molecules; I dodge molecules wherever I can.

X Q. 181. What are the reasons for your opinion that in the instance that I have given you there is a surface concentration of the oil?

A. Because under all circumstances so far as I know, where you have two surfaces in contact you do have an adsorption or surface concentration of something there. That is, so far as I know, no surface can exist without adsorbing greater or lesser amounts of something. What that will be depends on conditions. You may have a surface adsorption of a gas, of a liquid or a solid; but you have no surface that does not show a certain amount of condensation, so far as we know.

X Q. 182. Now, in the instances that I have given you, what was the thickness of the layer in which adsorption occurred?

A. I do not know; your layer may vary from a very thin one up to a distinctly thicker one. I do not see that there is any way in which you can speak of the different thicknesses of your adsorbed layer without describing your terms a great deal more accurately than you have yet done.

X Q. 183. Have you made any measurements of the thickness of the adsorbed layer of oil on metal?

A. I have not, but I can give you all the references to them if you want.

X Q. 184. I have The Chemistry of Colloids, by W. W. Taylor.

3218 A. I recognize the book.

X Q. 185. Will you take the statements in that book as fair statements of authority?

A. No, I will not; not unless they are verified, because the book is a very bad book, written by a man who did not know his subject and who has arranged his subject in the worst possible order. Anyone writing a book on colloids should begin with adsorption; while, if my memory does not fail me, he puts in a chapter on adsorption over towards the end of the book. It is written by a man who had very little knowledge of colloidal chemistry, who had done very little work. It represents an especially bad instance of hack work. Of course, I do not mean to say thereby that everything in it is wrong, because that would not be true, but you can not place any reliance on any statement in that book because the author put it there. If it can be checked independently, well and good.

X Q. 186. I will ask you to read that short paragraph on page 26, "Thickness of Adsorption Layer."

A. Out loud?

X Q. 187. No.

A. I have read it.

X Q. 188. Will you accept that as authority?

A. As authority in regard to what? On adsorption layer?

X Q. 189. Yes.

A. He is not talking about adsorption layer. There isn't any adsorption layer here. He is talking about the behaviour
3219 of water or any liquid, and not necessarily in the presence of gas or vapor, which would be adsorption; and the surface layer that he is discussing under these conditions is not the adsorption layer that you would have in case you had either vapor or gas. It is an entirely different thing.

X Q. 190. Suppose you give me some of your authorities.

A. For what?

X Q. 191. Thickness of the adsorption layer.

A. Certainly—hold on a minute. I said there wasn't any such thing as a definite thickness of your adsorption layer. I can give you the minimum values under certain conditions at which the adsorbed film can be detected, and I can give you various other val-

ues, but I can not give you any definite figure for the thickness of an adsorption layer, because there isn't any such thing.

X Q. 192. I so understood it, but you can give some indication of it. Please do so.

A. Minimum values.

X Q. 193. I think perhaps you had better start with the minimum values?

A. The minimum value that has been accurately measured as affecting the properties of the substance in question is of the general order of one one-hundred millionths of an inch, or three ten millionths of a millimeter.

X Q. 194. Now can you give us the range of the adsorption layer?

3220 A. The range of the minimum values?

X Q. 195. No, the range of values within which the adsorption action is manifested?

A. No, I can't give you that.

X Q. 196. How far can you go above the minimum?

A. I can give you, as I said, different minimum values; for instance I have here the smallest visible—the thinnest visible oil film is of the general order of one one hundred millionths of an inch. The oil film which is thick enough to change the surface tension of water is three times as thick as that. The film of albumin which is just thin enough to give you a so-called solid film on the surface is ten times as large as that, and we have other data of the same general order—those representing the minimum thickness.

X Q. 197. And you are talking now of a film on the surface of water?

A. The figure which I gave there was for the thinnest film of oil on the surface of water which can be detected by optical means, and is one one hundred millionths of an inch, or thereabouts. I can give it to you in millionths of a millimeter, if you prefer.

X Q. 198. I would rather have it in inches?

A. Well, in round numbers it is of the general order of one one hundred millionths of an inch, unless my arithmetic is bad.

X Q. 199. And when you get to the amount of film which will affect surface tension, as I understand you, it is in what figures?

3221 A. Just about three times as large as the minimum one that you can determine.

X Q. 200. And what is the book you are referring to, and the page, please?

A. The page from which I took those data is page 278 of the book to which reference was made the other day, Freundlich's Kapillar Chemie.

X Q. 201. And that book is a book that you would refer to as an authority?

A. Oh, dear, no. I would not refer to any book as authority. I am merely quoting the references which he gives, and I am not quoting them on the authority of Freundlich at all. These are simply the measurements given by certain observers, and I shall be

happy to give you their names if you like, and they represent their conclusions. I do not guarantee the accuracy of them in any way, but simply they are the best available information, and they are probably not very far wrong.

X Q. 202. Is surface tension due to molecular force?

A. I suppose in a sense you can say that everything might be due to molecular force. I would not commit myself on the subject at all; I would simply take it that we have surface tension as a matter of fact, and I don't care at all how you get it. You see as a matter of fact you can get exactly the same results experimentally and quantitatively whether we consider that as something analogous to a surface film, like a rubber band, more or less roughly, or whether we consider that we are dealing with an internal pressure, the
3222 particles of the liquid tending to go to the center—those two things are fundamentally different conceptions, but they lead, as far as I know, to exactly the same numerical results in regard to surface tension, and you can take one or the other as a working hypothesis to account for it, to suit yourself. There is no way that I know of of distinguishing between those two hypotheses, and consequently it is a great deal better to take your facts as you have them, and not as they might be.

X Q. 203. I did not put any hypothesis to you?

A. Oh, yes.

X Q. 204. I put the simple question, whether surface tension was due to molecular force?

A. That is a hypothesis.

X Q. 205. I ask you the question, is surface tension due to molecular force?

A. I can't answer that—I don't know.

X Q. 206. Is adsorption due to molecular force?

A. I don't know. That is merely a question of definition.

X Q. 207. Well, that is enough.

A. Certainly.

X Q. 208. Mr. Kenyon has called my attention to the fact that in that part of Dr. Liebmann's testimony which I quoted, I should have read the next question, commencing page 1853, X Q. 2053. "It is nothing else; it is simply phenol? A. It possibly contains a trace of water. It is a remarkable thing that phenol by itself forms cresylate, melting at about 45 per cent; that is, it liquefies, but the
3223 part that is absolutely insoluble has the qualities of oil, you must remember, with the water." I have read that correctly, have I not?

A. You have read that correctly.

X Q. 209. Now, has your study of the process that is here involved included—have you seen the process here in suit operated on a commercial, or continuous scale, and if so, when and where?

A. You mean this agitation froth process?

X Q. 210. Of ore concentration?

A. Well, I strolled casually through the plant of the Butte & Superior Company the first Sunday afternoon that I was here.

X Q. 211. About two weeks ago?

A. It must have been Sunday the 15th, I think, and that is the extent of my knowledge of the technical process, if you can call that an extent.

X Q. 212. Now, I show you an article printed in "Metallurgical and Chemical Engineering," dated June 1st, 1916, pages 1631 to 1635, entitled "Ore Flotation," a paper read at the joint meeting of both sections of the American Institute of Mining Engineers and the American Electro-Chemical Society, on May 12th, 1916, by Wilder D. Bancroft. Is that the paper that you read at that society at that time?

A. It is, or rather this article is based on what I said there. I do not mean to say that I said everything in the talk that is in here, or vice versa, but this article is an article based on that lecture,
3224 written up from my lecture notes, so that I imagine it gives substantially what I said at the meeting, but as I spoke from notes only, I would not want to guarantee that.

X Q. 213. I notice at the end of the article the words "Cornell University." Apparently as though this were something that was written at the university and reprinted. Of course, I merely want to refresh your recollection about the matter?

A. Not at all. I always put Cornell University at the end of all articles that I write; I would do it even if I were to write an article out here before I went home—which I am not going to do, by the way.

X Q. 214. Well, you wrote this?

A. I wrote this, certainly.

X Q. 215. Now, I read from this article as follows—do you want to follow me?

A. Well, I should like to have a copy; it will be easier to follow it; in fact I should like to keep it, because I haven't a copy myself.

X Q. 216. We can spare that one; you may have it.

A. Thank you.

X Q. 217. "When discussing the theory of ore flotation people are apt to lay more stress upon surface tension in general and upon contact angles in particular. While this is entirely legitimate, it seems undesirable, because we cannot measure a contact angle with any accuracy, and because the actual existence of a contact angle is a matter of doubt." Have I read that correctly?

3225 A. You have.

X Q. 218. Was that your opinion at the time that you wrote this article?

A. It was.

X Q. 219. Is that your opinion now?

A. It is.

X Q. 220. I will now read also from the article a foot note, referring directly to the part that I have read: "Rayleigh Scientific papers, three, 354, 1902." That is correct?

A. That is correct. I should like to add one statement, which may or may not have a bearing on this. I wrote this article, but I did not read the proof of it, so that it is possible that there may be some typographical errors. I don't know that there are.

X Q. 221. From page 634 of the article I read as follows: "So far we have been considering the case where we have a fair amount of oil. If we cut the amount of oil down (almost to the vanishing quantity), another factor comes in, namely, air flotation. When sufficient quantities of oil are used the air floats the oil and the oil floats the ore. The ore is enclosed in a drop of oil having the properties of the matter in mass, and sinks to the bottom of the drop of oil, distorting it to a greater or lesser extent. If the amount of oil is decreased sufficiently we no longer have an oil drop surrounding the particle of ore, but an oiled particle, the lower part of which is, or may be in contact with water, while the upper part is in contact with air. We are, therefore, getting air effect in addition to the
3226 oil effect. I do not know the relative importance of these two effects, but it has been claimed—and disputed—that modified air flotation is very much greater than the other." Have I read correctly from your paper?

A. You have read correctly.

X Q. 222. Did that at that time represent your views, your opinion?

A. It did.

X Q. 223. Is that your opinion now?

A. I think I would word that a good deal differently now.

X Q. 224. I will read further, and immediately following what I read: "In the Wood & MacQuisten processes there is no doubt that the separation would be more effective if it were possible to cover the ore particles with a thin covering of stearin, leaving the gangue particles uncoated. It is very difficult to wet the stearin coated commercial copper and aluminum powders, and it is therefore very difficult to make them sink under water. In modern processes of ore flotation using very little oil per ton, you get a thin coating on the ore, analogous to the stearin coating on the copper or the aluminum powder. It is possible that the air film may surround the oil particle completely, so that the oil does not come in actual contact with the water. In that case we are back to a straight air flotation of the oiled particles. This point calls for further study, because, if established, it will have a very important bearing on the future development of the subject." Have I read correctly from your article?

3227 A. You have.

X Q. 225. Did that then express your views?

A. It did, but it does not now.

X Q. 226. Does it now?

A. It does not.

X Q. 227. I will read further, immediately following: "It is under these circumstances that the addition of more oil causes the ore to cement together and to sink. The reason for this will perhaps be seen more easily if we consider the analogy of sand and water. When enough water is mixed with sand you get a quicksand, over which it is unsafe to walk. With only a little water you get a plastic mass over which it is a pleasure to walk and out of which children can make forts and pies, etc.,"——

A. I will endorse that still (laughing).

X Q. 228. "When the sand dries out, more air gets in between the grains, and walking becomes hard, though the sand is by no means dry from a chemical point of view. When the amount of oil around the ore particle is sufficiently small, the air gets in and makes a froth possible; with more oil you get a plastic mass; with still more you get the bulk oil process." Have I correctly read from your article?

A. You have.

X Q. 229. Did that represent your views at that time?

A. In a sense, yes. It might be said more accurately to represent what Dr. Grosvenor told me the afternoon before the lecture.

3228 X Q. 230. Does it represent your views now?

A. It does not.

Mr. Williams: That is all.

Redirect examination.

By Mr. Scott:

R. Q. 231. Have you any comment to make, Professor Bancroft, on the passages from this article which were read to you, about ore flotation?

A. I think the simplest way of dealing with this article is to say that it represented my views at the time I wrote it; that all parts in it which are inconsistent with the testimony that I gave yesterday are wrong to the best of my knowledge and belief, and very likely certain other portions in it are also wrong. With those exceptions it represents my views today.

R. Q. 232. Can you describe any experimental proof of the existence of viscosity in the surface film?

A. That can be measured in different ways. If you suspend a needle by a fine string and let it go down into the mass of a liquid, and then cause it to swing by means of a magnet or in any other way, you will find that you get a definite rate of damping, as it is called, or slowing down of the swing of the needle. If you do that same thing in the surface of a solution where the surface tension is lower than that of the pure liquid, and where the surface film is supposed to have an increased viscosity, you find that the needle comes to rest very much more quickly, showing that there is a distinctly

3229 greater resistance to the swinging of the needle. That experiment can be modified in all sorts of ways, but it comes to much the same general thing. The existence of a film at the surface having a lower surface tension than the mass of the liquid can also be shown very easily, because if you produce suddenly a fresh surface from somewhere in the mass of the liquid, that would then give you, on a momentary reading, a surface tension corresponding approximately to that of the concentration in the bulk of the liquid; it won't do it absolutely because it would be changing right along; consequently you would expect to find, if you made a rapid measurement of the surface tension of a fresh surface, say of a saponin solution or a soap solution, that it will be higher than if you measured it on an old solution. I can give you some more data in regard to that if you

wish it. These data are on page 56 of the same book to which reference has been made before, Freundlich's Kapillar Chemie. These are determinations at room temperature of a saponin solution; the value of the surface tension of a fresh surface is about 73, while the surface tension of water is about 75; it is nearly up to the value of pure water. The value of an older surface is 52; thus the difference between the surface tension of the mass of the liquid when measured as rapidly as you can, and the surface tension of the surface film is the difference between 73 and 52, showing, you see, that there has been a concentration of the saponin in the surface film. There are other data here, but that one will do as a illustration.

3230 Mr. Scott: That is all.

The Court:

R. Q. 233. When did you commence lecturing on flotation?

A. In the autumn of 1912, and I have been carrying that out, a little under a lecture to a little over a lecture on flotation ever since then.

Recross-examination.

By Mr. Williams:

R. X Q. 234. Just one part of your testimony here I don't quite understand. On page 1092 in describing a certain experiment you say that the materials that you used, you were told contained 1% mineral in one experiment, and in another experiment that it contained 65% mineral. Do you mean the metal or the metalliferous mineral?

A. I was told that in both cases the content was 1% mineral and 65% mineral. What it really was, I said I didn't know.

R. X Q. 235. Of course you know it is customary to state the values in the metal, as for instance 1% zinc sulphide, would be .66% zinc; and these values are customarily stated in the metal, and we have to add to that what the sulphur would add. You did not do that in this instance, did you?

A. I don't think that can be true. If that were true of the concentrates, the concentrates would be pure zinc sulphide. I don't know—the figure that was given to me in both cases was 1% mineral and 65% mineral. Whether it was that or whether it
3231 was anything else between 100 or one-tenth of 1% I have absolutely no knowledge. I didn't analyze them.

Witness excused.

Mr. Scott: Mr. Williams has submitted to me a form of agreement that we are agreed upon as to the manner of presenting this testimony regarding mill operations. I will just read it as it is written, I think, and will let it go into the record:

"We are willing to enter into a stipulation with the defendant respecting the testimony of Mr. Dosenbach and other witnesses with

respect to operations at the Butte & Superior plant to the following effect:

"We are to be furnished with a flow sheet of the defendant's mill with respect to any operation about which the witness is to testify.

"We are to be permitted to inspect the mill in order to see how the plant is operated, so as to ascertain the source of the important details from which determinations are to be made.

"We are to be shown whatever typical original reports of the different steps in the operations and of different characters and kinds of original reports and compilations thereof we demand.

"After which Mr. Dosenbach and other witnesses as to operations and results at the Butte & Superior mill may testify to compilations made up by the witness and from data from other sources
3232 than his own personal knowledge, provided the defendant undertakes to furnish the original and best evidence as to anything so testified to by the witness that we demand, and if the defendant does not do so the testimony not thus justified shall be stricken from the record:

"Provided that either party may produce witnesses as to regular operations and results at other mills than that of the Butte & Superior without producing the original or best evidence if such witness has inspected the operations in question and the results and has knowledge of the details derived from inspection of the regular reports of others made at the time."

And we are mutually agreed to enter into that arrangement.

The Court: The record may show that.

Mr. Garrison: I only want to say, in connection with this stipulation, your honor, that has just been entered into, that we wish to advise counsel on the other side that if they propose producing Mr. Dosenbach or any other witness with respect to the Butte & Superior mill and its operations we shall require sufficient notice and opportunity to inspect the mill within a reasonable time before the testimony of the witness, so that they may not be surprised that we object if we had not been given that reasonable opportunity. I think it is proper to say that at this time.

Mr. Kremer: In pursuance of the notice just given, we desire to state that we will produce Mr. Dosenbach as a witness and under the stipulation just entered into certain matters would be necessarily available to you, and you desire an inspection of the mill.
3233 We now tender you that privilege, and if it would be satisfactory, and satisfactory to the court, you may make that inspection today, this afternoon.

Mr. Garrison: Oh, we could not possibly make it in so short a time as from the adjournment of court. We shall need a very much longer time than that.

The Court: I suppose they will allow you to go in any time.

Mr. Garrison: He said today.

Mr. Kremer: Yes.

Mr. Garrison: But you see our men who are at all available will be here in court until something like four or five o'clock.

The Court: I don't suppose they will limit you to one day.

Mr. Garrison: He said today.

Mr. Kremer: My statement carried with it the suggestion that they might take this afternoon if it would save time. I have no doubt your honor would be willing they should take it.

Mr. Garrison: We do not want to be limited to any brief time. When do you propose to produce Mr. Doesenbach?

Mr. Kremer: Monday.

Mr. Garrison: Can we have the inspection on Sunday?

Mr. Kremer: Yes, I think so. I do not want to say that they can have it and then have a part of the mill shut down.

Mr. Garrison: We can't possibly do it in two or three hours.

3234 Mr. Kremer: Have all day tomorrow.

The Court: Haven't you had an inspection?

Mr. Garrison: No, sir.

Mr. Kremer: The mill will be running all day tomorrow.

Mr. Garrison: Then we may have the inspection tomorrow?

Mr. Kremer: Any time you please. Will you designate who will make the inspection for you, and the time?

Mr. Garrison: I will give all of that after recess; I will fix it at lunch so as not to keep the court now, while we confer. Is that satisfactory?

The Court: Yes.

E. W. ENGELMANN, recalled on behalf of the defendants, having been previously sworn, testified as follows:

Direct examination.

By Mr. Scott:

Q. 1. Mr. Engelmann, will you first state what records, and what is the extent of the information you have with you, so we will know before we start.

A. I have the result, the tonnages, the assays and the amount of oil used for every day since the beginning of operations in 1914.

3235 The Court:

Q. 2. Has this witness been on the stand before?

The Witness: Yes, sir.

The Court:

Q. 3. What company are you from?

A. The Ray Consolidated Copper Company, Hayden, Arizona.

Mr. Scott:

Q. 4. I think you stated your employment and education when you were on the stand before, didn't you?

A. Yes, sir.

Q. 5. Now, you—if you were asked about the details of any par-

ticular day that occurred in these quarterly periods you can give that information, can you, as to the particular days?

A. Yes, sir.

Q. 6. Regarding the amount of oil or other factors?

A. I can.

Q. 7. What kind of material do you treat by flotation at the Ray Consolidated Copper Company?

A. We have two different products; one we call our retreating plant feed. It consists of a concentrate made on the vanner. The other is our slime vanner tailing, which is the tailing from the slime vanners.

Q. 8. About what tonnage do you treat per day?

A. We treat approximately 7,000 tons of slime vanner tailings per day and 350 tons of retreating plant feed—that is, by flotation.

Q. 9. Have you a summarized statement of the operations on these various concentrating products?

3236 A. I have. Do you want it for months or quarters or years?

Q. 10. Quarters I think will do to start. Will you just read the title of the paper you are going to refer to, so we can identify it?

A. "Ray Consolidated Copper Company, Hayden plant, Flotation Operations Retreating Vanner Concentrate Products."

Q. 11. Now what period of time does that statement cover?

A. From the last quarter of 1914 until the first of April, 1917.

Q. 12. You were in charge of those operations throughout this period or were familiar with them?

A. I was in charge of the operations throughout the entire period.

Q. 13. The first column there of this tabulation sets forth the total tons treated by flotation in each of the periods mentioned, I take it, from the heading?

A. It does.

Q. 14. The second column is the assay of the copper in the heading. Now the No. 2 columns there, they are the tonnage and the copper assay of the flotation concentrates?

A. They are.

Q. 15. Now, under the heading "Flotation" you have "Copper Recovery." Will you explain the heading, the average of those two columns?

A. Under the "Copper Recovered" we have "Apparent"
3237 and "Estimated," but in this particular case we derive our flotation tonnage of concentration from our ratio of concentration which is derived from our assay. So consequently our apparent recovery and estimated recovery are both derived from the formula as given in one of the engineering journals that we adopt throughout all our plants and are practically the same.

Q. 16. Now, "New Oils Per Ton." The heading of the next column there: I take it that simply refers to the actual measured or weighed amount of oil that is fed into the pulp per ton of solids in the pulp?

A. Yes, sir.

Q. 17. Now, we come to the heading "Oil Assays." Will you explain that? "Flotation Heads, Including Circulating Loads"?

A. The column "Flotation Heads, Including Circulating Loads," represents the amount of new feed plus the circulation tonnage against the amount of new oil, plus the circulating oil. That actually represents the pounds or per cent. of oil in the total feed. The next column, the "Concentrate Assay," represents the per cent. of oils that go to our final installation in the concentrates; and the third column represents the per cent. of oil that is in our tailings, going to waste.

Q. 18. How do you measure the circulation tonnage?

A. These circulation tonnages are measured at intervals of every hour in special tubs built for measurement. These tubs are
3238 6 feet in diameter and approximately 5 feet high. We run the total feed into these tubs for a period of two or three minutes and take the per cent. of solids at the same time we run the feed into the tub, thereby referring to the table, we have compiled, we get the tons of solids per day circulating.

Q. 19. You maintain a steady and uniform feed from day to day?

A. We do.

Q. 20. How are your circulating loads sampled and determined for oil analysis?

A. I can best explain that by reading our method.

Q. 21. Before that possibly it would be better to explain the arrangement of the flotation plant. Have you any sketch that will serve for a flow sheet?

A. I have. I submitted one the last time for this plant, but I have another one here.

Q. 22. You gave one to counsel the other day?

A. No, I didn't get it. Here is one here, though.

Q. 23. What one are you going to use to put in evidence?

A. There is one in evidence already. (Exhibit No. 45.)

Q. 24. Now, I think you commented on this some the other day, but I think in order to get this clearly before us you might briefly refer to it again. Maybe if you put it on the desk the court could see it at the same time you are explaining it.

Mr. Williams: I will lend your honor my copy.

A. The original feed goes into a small pump sump, and is
3239 pumped from there into the back of the first emulsifier. We have two emulsifiers in series. The discharge from the emulsifier is evenly distributed between five cells in multiple. These are Janney and mechanical flotation machines. And we make a finished concentrate on the five cells in multiple. The tailings from each individual cell in multiple join as one product and go to a series of five cells in series. The fourth or middlings from these five cells in series goes back and joins our original feed, this getting to the head of the first emulsifier. The tailings from the last cell in series go to waste. The oil is added at the sump, where the original feed and circulating load go to the pump. Now we will come back to our question as to how the circulating loads are sampled and determined for oil analysis.

Q. 25. Will you make an indication on here as to the position?

A. Yes.

Q. 26. If you wish to, then we will have it all on the one exhibit.

A. "Method for Sampling and Determination of Oil in Pulp Used at Ray Consolidated Copper Company, Hayden Plant. Hayden, Arizona.

"Sampling. Samples are taken by hand in a metal sample cutter. The form and principal dimensions are as follows: The body of the cutter is cylindrical in shape approximately four inches in diameter and eight inches high. The cutter is held in hand by a loop handle similar to the usual tin cup handle. Opposite the
3240 handle is placed a spout extending at the top nine inches from the bowl and tapering from this outer edge to the bottom of the bowl with parallel sides one inch apart.

"In sampling this cutter is moved across the stream of pulp at such a rate as the sampler knows by experience will furnish a sample containing approximately one hundred grams of solids. This sample is transferred to a white enamel pan and brought to the laboratory for test.

"Determination of oil: The samples are immediately filtered upon receipt in the laboratory. This is performed in a Buchner funnel with suction. The pulp still moist upon the filter is then treated with successive small portions of chloroform which almost completely removes the oil, the latter being caught in the filter flask in chloroform solution.

"The chloroform is displaced upon the filter contents with water and the pulp is removed to a low temperature drying oven (temperature 140° F.) and dried over night.

"The chloroform solution of the oil is separated from the water in a separatory funnel and placed in a small weighed flask. The chloroform is then distilled from the flask through a deflegmation head and recovered.

"When the distillation of the chloroform is almost completed, the flask is removed and the evaporation of the remaining chloroform accomplished by very gently warming with a soft flow of air into the flask. After cooling, the flask and contents are weighed and weight of oil noted.

3241 "When dry the pulp is weighed and thoroughly mixed by rubbing in a glass mortar. Thirty grams are taken for extraction dry in a Soxhlet extractor and after extraction the oil recovered is weighed in small flasks, the chloroform being removed by evaporation as with the oil extracted wet.

"The weight of oil extracted dry is calculated to the equivalent for the whole sample and added to the amount previously recovered.

"The percentage of oil in dry pulp is then calculated from the total weight of oil and the weight of solids."

Mr. Williams:

Q. 27. Now, you have read that from a document which you had before you. Did you write that yourself or dictate that?

A. No, sir; that was dictated by Mr. Johnson, our oil expert.

Mr. Williams: I suppose he knows more about that particular thing than you do, and you thought you would rather have his views?

A. Absolutely.

Mr. Scott: If you object to it, I am not at all particular.

Mr. Williams: No, I do not object.

The Court: What is this?

The Witness: Analysis of oil determination.

Mr. Williams: It is highly technical. I wanted it to appear that he was not testifying to it, but was reading what his oil expert said, to which I have no objection.

3242 The Court:

Q. 28. This is the oil in the circulating load?

A. Yes, sir, and in the concentrates and in the tailings.

Mr. Scott:

Q. 29. And at what point are those samples taken for oil analysis, referring to this flow sheet? You might place a letter at each place you sample so that we will know.

A. "A" represents the tub where we measure our circulating load. "B" represents the point at which we take our sample for oil determination in our concentrates. "C" represents the point at which we take our determination for oil analysis in our tailings.

Q. 30. How do you measure the new oil that you add? I think you said at the pump sump.

A. It is added at the pump sump, but it is measured by a circular tank which has a reservoir, and we have a gauge glass graduated in eighths and quarters and halves and inches; and these are read at intervals of each hour, and the oil is fed with a mechanical feeder. These oils are checked against our total oil consumption for the month in our large storage tank out of the mill.

Q. 31. Will you state what quantities of oil you have used during the period flotation has been operated—I mean the range of quantities and when you changed from one quantity to another—that is, any marked change. I see up to the end of 1916 your quantities ran quite uniformly. Then beginning with 1917 they increased.

3243 A. Well, for the last quarter of 1914 to the end of the year 1916 our oil has only varied from 3.22 pounds per ton at the minimum to 5.28 pounds per ton maximum, for that period of time. After the year 1916, beginning January, 1917, we used 20.02 lbs. per ton, and in the month of February we used 18.77 lbs. per ton. From then to March we used 21.19 lbs. per ton.

Q. 32. Referring to the columns giving the assay of the concentrates and tailings and recovery, will you state in a general way how the results that you have obtained since January 1, 1917, compare with those prior thereto?

A. For the years and quarters previous to 1917 we have maintained a slightly better grade of concentrates than we did to the year 1917. Our tailing has been—Well, for the year 1914 we made a

.617 tailing; for the year 1915 we made a .502; for the year 1916 we made a .375 and the year 1917, when using excess oil, we made a tail of .412. That is, including the month of March. Now, in the year 1914 we made a 92.94% extraction using 4.31 lbs. of oil per ton. The year 1915 we made 93.43% extraction using 4.21 lbs. of oil per ton; the year of 1916 we made 94.69% extraction using 3.36 lbs. of oil per ton, and for the first quarter or up to the first of April of 1917 we made 95.42% extraction with 20.1 lbs. of oil. Our extraction for the year 1917 has been the highest we have maintained since the beginning of operations.

Q. 33. How many pounds of copper per ton does the
3244 difference between 94.69% recovery in 1916 and 94.42% recovery for the first quarter of 1917 represent?

A. Well, according to my figures I have saved for the year 1916, 105 lbs. of copper per ton, and during the year 1917 122 lbs. of copper per ton.

Q. 34. That is 17 lbs. more in 1917?

A. Seventeen pounds more.

Q. 35. Per ton?

A. Yes.

Q. 36. Now, I notice that in the first quarter of 1917 you treated 28,913 tons. That would be a saving of 17 lbs. of copper for each ton in 1917 as compared with 1916, on the basis of these two recoveries?

A. Yes, sir.

Q. 37. About how much additional expense is involved in this extra oil you are using; about how much does that cost additional?

A. Well, we changed our oil proportions. Previous to the year 1917 we were using—well, we were using 75% of Barrett's No. 4 and 25% of fuel oil. That was the general trend of operations during that year. And, during the year 1917 we changed our oil to 90% fuel oil and 10% Barrett's No. 4. Now the Barrett's No. 4 is our expensive oil and our fuel oil is very cheap oil, but as far as the cost of oil per ton, I really have never figured it. Our fuel oil only costs us 3½ cents a gallon and our Barrett's No. 4 costs 36 cents
a gallon, so we have used quite a large proportion of the fuel
3245 and cut down on the Barrett's, thereby cutting down our oil cost considerably—that is, the mixture.

Q. 38. What different kinds of machines have you used, and what were the tonnages when running with 20 lbs. of oil or over, during the first quarter of this year?

A. That is, you are speaking of the machines used in the retreating vanner concentrates?

Q. 39. Yes, confine it to that for the present.

A. We have only used the one machine on vanner concentrates and that is the straight Janney Mechanical Machine.

Q. 40. What kind of apparatus did you—do you use in treating the slime vanner tailings?

A. Well, we have three different kinds of machines. Our plant is composed principally of the Janney Mechanical Air Cell. It is similar to the mechanical machine only it has the air basket in the

spitzkasten. Then we have what we call a straight air machine which is similar to the Inspiration type machine.

Q. 41. You may describe that briefly, the straight air machine.

A. I have——

Q. 42. (Interrupting.) I think the description will be enough without any drawing.

A. I have the drawing here if you want it. It is simply a long, rather narrow machine. The compartments are approximately three feet square and we have 16 cells in series.

3246 Q. 43. How is each cell made; what is its construction, how do you put the air in it?

A. Each cell has a filter medium at the bottom.

Q. 44. A porous bottom of some kind?

A. Yes. And the air is injected through this porous bottom and coming in contact with the pulp, and each cell has an overflow launder for the concentrates, and the tailings from one cell go to the next, right down through the 16 cells, until we have the final discharge at the last cell, and this total concentrate is considered one product, our rougher concentrate; it is recleaned in six cells of similar type, a recleaner. The tailings from this cleaner come back to the ninth or the middle part of the roughing machine.

Q. 45. Have you got the diagram of flow sheet of that?

A. I have, right here. These are separate platforms, numbered 1 to 16.

The feed comes in at the head of cell No. 1. From that cell we receive a concentrate and the tailings go to No. 2 and No. 3 and No. 4 and on until we get final discharge from cell No. 16, which is the tailings to waste. The concentrate passes from all these cells combined as one product and goes to our retreating machine, which is the same machine only six cells in series. The concentrate from the six cells in series or the retreating machine goes out as a finished product. The tailings come back to cell No. 9, or practically the middle of the roughing machine.

3247 Q. 46. Where is the oil added to the pulp in this air machine?

A. It is added with the pulp at the head of No. 1 cell.

Q. 47. And where are samples taken for oil, assay, etc.?

A. The sample for oil assay is taken—"A" would be right in the cleaner tailings, circulating back, and "B" would be the concentrate product from the cleaning machine. I think we have an assay on out tailings in that machine. Yes, I have one. "C" is the assay of the tailings which goes to waste.

Q. 48. Now, you have other machines in the slime production you said?

A. Yes.

Mr. Scott: I think I will offer this in evidence, this being entitled "Ray Consolidated Copper Company, Air Machine Treating Slime Vanner Tailings."

The paper admitted in evidence and marked Defendant's Exhibit 149.

Q. 49. Now, if you will describe the other machine.

A. Our main installation treating plant treats 7,000 tons of slime vanner tailings per day, the concentrate of the Janney Mechanical Air Machines. We have the flow sheet of that which is somewhat more difficult to follow than the previous flow sheet submitted.

Q. 50. You might produce that flow sheet, please.

(Witness produces the sheet.)

3248 Q. 51. What tonnage passes through that air machine you just described?

A. We treat from 300 to 415 tons, I think, per day.

Q. 52. Per day?

A. Yes, sir.

Q. 53. And this is by far the larger part of the slime plant?

A. This is practically the whole slime plant outside of the air machine. This set of machines treat practically 7,000 tons of ore per day. We have two pyramids.

Q. 54. Just explain how you use that word "pyramid."

A. Well, it consists of one cell above the other, the original feed coming into the first row of cells, the tailing from that row of cells goes to the next row and the tailing from that to the next one, and the tailings from the last row, to waste. Just four machines in series, one above the other.

Q. 55. And that machine at the ridge, part of the tailings from that go each way, part goes down to the machine on one side and part to the machine on the other?

A. Yes, equally divided to both sides of the pyramid.

Q. 56. And what does each of these circles with an "X" in it, represent?

A. The machine, represents one row of machines.

Q. 57. The Janney agitating machine?

A. Mechanical air machine.

3249 Q. 58. You have written on this drawing eight rows of cells. I take it that this drawing simply represents one row?

A. Yes.

Q. 59. Have you a photograph of it?

A. Yes, I have. There is the side.

Q. 60. Altogether how many of the Janney cells are there in this whole system?

A. There are 140 roughing cells and 45 cleaning cells.

Q. 61. Now, will you describe the flow of the pulp?

A. The feed and oil go to two emulsifiers.

Q. 62. Where are they?

A. They are at the head of the pyramids in multiple.

Q. 63. Represented by this machine, that box there?

A. No, no, they are in a pit, below the pyramid, and the discharge from the emulsifier goes to elevators which elevate the feed up to the first row of cells of the pyramid. Our original feed goes to the first row, and from there the tailings is distributed evenly to both sides; it goes to another row. The tailings from the second row go to the third row, and the tailings from the third row go to the fourth row,

and the tailings from the fourth row go to waste. The concentrate produced by the first, second and third rows make up what we call the rougher concentrate. The concentrate from that fourth row circles back to the head of the elevators which feed the first row.

3250 The rougher concentrates go to two elevators and are lifted up and go through 15 Janney multiple cells. The tailings from these go through 15 more in multiple, and the tailings from the last 15 cells, which we call our primary cleaner tailings, circles back to the elevators at the head of the rougher machine. The concentrate from the primary cleaners go to one elevator and from there through 5 multiple cells followed by five multiple cells, followed by five more multiple cells, and the tailing from the first five go to the second five, and from the second five to the third five, and the tailings from the third five go back to the head of the primary cleaning system. The concentrate from the secondary cleaning machines go to filters as a finished product.

Q. 64. About how fine is this material that you speak of that is treated in the slime plant?

A. Approximately two per cent on a 65 mesh, and seventy per cent through a 280 mesh.

Q. 65. How about the material treated at the retreating vanner concentrate; about what is the screen analysis of that?

A. 6.12 per cent on a 65 mesh and 45.61 through a 280 mesh.

Mr. Scott: I offer the first tabulation referred to by Mr. Engleman, the one entitled "retreating vanner concentrate products."

Tabulation admitted in evidence without objection and marked Defendant's Exhibit No. 150.

Q. 66. Have you a tabulation of the operations of treating the slime vanner tailings by flotation?

3251 A. I have.

Q. 67. What period of time does this tabulation cover?

A. From the second quarter in 1915 to March 26th, inclusive, 1917.

Q. 68. I notice on this tabulation that beginning in the month of January, 1917, the amount of oil was increased. Will you just briefly compare the recoveries and assay of the concentrate before and after the increase in the amount of oil?

A. During the year 1915 we consumed 1.71 pounds of oil per ton. Our tailings assayed .572, which would indicate an extraction of 38.2. During the year 1916 our consumption of oil was .85 pounds per ton and the tailing assay was .419, indicating an extraction of 45.64. During January 17th and 18th, 1917, our coal tar consumption was 20.3 pounds per ton and our tailing assay was .465, with an indicated extraction of 43.56. During the month of February 8th to 28th, a period of 20 days, we consumed 20.1 pounds of oil per ton, maintaining a tailing of .375, with an indicated extraction of 45.25.

Q. 69. Now, what kind of machines were those operations con-

ducted in for those two periods January 17th and 18th, and February 8th to 28th?

A. For the period of January 17th and 18th, we made the runs with our pyramid installation, that is, the machines treating our big flotation tonnage. The period between February 8th and 28th inclusive, we made the runs on the air machine which was described previously.

3252 Q. 70. What makes the difference between the grade of the concentrate on January 17th and 18th, as compared with February 8th to 28th?

A. On January 17th and 18th during the run our flow sheet was practically the same it is ordinarily, as we had two recleanings, a double system of cleaning; but for the period February 8th to 28th the air machine is so arranged that we get only one cleaning, and we maintain a concentrate equally as high as our normal grade of concentrate from the primary cleaner; that is to say, the normal operation in previous years from the primary cleaner concentrate was an average between eleven and a half and thirteen per cent.

Q. 71. Then all these entries after the first, during the year 1917 represent operations with one cleaning?

A. No.

Q. 72. Will you state just which ones represent one cleaning and which represent two cleanings?

A. Well, January 17th and 18th, there were two cleanings. February 8th to 28th there—that was only one cleaning. March 1st to 14th there was only one cleaning, and March 15th to 17th there were two cleanings; March 20th to 26th were two cleanings. Now the result: On January 17th and 18th and February 8th to 28th and March 1st to 14th the results were obtained with one oil, while the results from March 15th to 17th and March 20th to 26th were obtained with another oil.

Q. 72½. They were both mixtures, both of these oils, or was it a single oil?

A. March 17th and 18th, February 8th to 28th, March
3253 1st to 14th were obtained with straight coal tar. For the other periods, March 15th to 17th were obtained with fuel oil principally, and a small amount of Barrett's, and the results from March 20th to 26th were obtained with floteo No. 20, and floteo No. 21. I have an explanation of the machines, how many cleanings and the product received at the bottom of the report.

Mr. Scott: I offer this table entitled "Ray Consolidated Copper Company treating slimes vanner heading and slime vanner tailing."

Tabulation admitted in evidence and marked Defendant's Exhibit No. 151.

Mr. Scott: I offer the flow sheet referred to by the witness, entitled, "Janney Mechanical Air Cells of Pyramid Installation Treating slime vanner tailings."

Tabulation admitted in evidence and marked Defendant's Exhibit No. 152.

Mr. Scott: I offer in evidence a photograph of the pyramid machines referred to by the witness.

Photograph admitted and marked Defendant's Exhibit No. 153.

Q. 73. Will you describe any experiments you have performed with different amounts of oil and what the purpose of performing those experiments was?

A. We performed experiments using different amounts of oil both for the retreating plant feed and our slime feed, and
3254 the purpose of those was to see if it was possible to maintain nearly the same results by using the different quantities of oil. On March 30th and 31st and April 1st, a period of three days, we treated by flotation in our retreating plant feed, using an oil mixture of ninety per cent fuel and ten per cent Barrett No. 4. We treated 1125 tons with 22.24 pounds of oil per ton, and made a concentrate of 21.48 per cent copper and a tailing of .32 per cent, with an indicated extraction of 96.14 per cent. During the period April 3rd, 4th and 5th, on our retreating machine, using the same oil mixture, 90% fuel and 10% Barrett No. 4, treating 1133 tons, we consumed 11.27 pounds of oil per ton and maintained 21.28 per cent copper concentrate and .290 per cent copper in the tailing, with a 96.67 per cent extraction. On March 30th, 31st and April 1st, treating our slime vanner tailing with straight coal tar, treating 795 tons, consuming 22.41 pounds of oil, we made a tailing of .375 per cent copper, an indicated extraction of 47.63. During the period April 3rd, 4th and 5th, while treating our slime vanner tailing, using straight coal tar, treating 772 tons of feed and consuming 11.2 pounds of oil per ton we maintained .366 per cent copper in tailings, with an indicated extraction of 46.15.

Q. 74. How do these results compare metallurgically with the larger and smaller quantities of oil?

A. Well, we maintain on our retreating machines month in and month out approximately 96 per cent extraction, which corresponds very closely with the extraction made on these runs. On our
3255 slime feed we maintain for months at a time between 40—42 and 46 per cent extraction.

Q. 75. When you say you maintain you refer to operations before the first of January, 1917?

A. Before the first of January, using small amounts of oil.

Q. 76. Yes.

A. Now, during these runs the operation was kept normal at all times; we simply increased the oil, and that is the only change in the operation that we made.

Q. 77. With reference to the statement you have just made, the figures you gave are from this table headed "Ray Consolidated Copper Company, comparative results obtained from air machines and retreating machine when consuming more than one per cent of oil per ton and also one half of one per cent of oil per ton, using the same mixture throughout." That is the table you refer to?

A. Yes.

Q. 78. Now, as to the results obtained on your table, there is a tabulation of the results obtained by eliminating fuel oil from the oil mixture; what was the purpose of that operation, eliminating the fuel oil?

A. I simply eliminated the fuel oil from the oil mixture to see whether we could maintain results. We tried at different times to run on straight fuel oil, but we could never maintain metallurgical results; so we eliminated the fuel oil and used the same out of Barrett No. 4—approximately the same amount that we
3256 used in the mixture of both, and on April 7th on our retreating plant feed using straight Barrett No. 4 on 344 tons, consuming 2.39 pounds of Barrett No. 4, we made a tailing of 1.083, with an indicated extraction of 85.95. On April 8th, on the retreating plant feed using straight Barrett No. 4, treating 356 tons, consuming 1.31 pounds of oil, which corresponds to the amount of Barrett used when we consumed 11.27 pounds of mixture, we got a tailing of 1.25 with an indicated extraction of 82.89 per cent. Now, on April 7th the extraction through these figures represents a decrease of 10 to 14 per cent by eliminating the fuel oil. On April 7th while treating slime vanner tailings using straight Barrett No. 4, treating 245 tons, consuming 2.07 pounds of Barrett No. 4, we made a tailing of .456, an indicated extraction of 33.65. On April 8th, treating the slime vanner tailings, treating 273 tons, consuming 1.13 pounds of straight Barrett No. 4, we maintained a tailing of .543, or an indicated extraction of 25.39.

Q. 79. Those last two operations, on the 7th and 8th of April, compare with what other amounts?

A. Well, they don't compare with the results on March 30th or 31st and April 1st when we used large quantities of oil, because on those days we used straight coal tar. I then simply ran the straight Barrett on our slime feed to see if it was possible to maintain our percentage of extraction with straight Barrett. We found that it fell practically 15. per cent below.

Mr. Scott: I offer in evidence the tabulation referred to
3257 by the witness, quoted "Comparative results obtained by air machines and retreating machines, etc."

Tabulation admitted in evidence without objection and marked Defendant's Exhibit No. 154. (Two sheets.)

Q. 80. Do you have any difficulty in getting the necessary oil for these flotation operations?

A. We have very little difficulty in getting the oil necessary for one per cent of oil in our feed on our retreating machine, but we have very great difficulty in getting enough of the oil that we use on our slime treatment; it has practically been to date impossible to get enough oil to continue operations daily with the use of more than twenty pounds of oil per ton on 7000 tons of feed.

Q. 81. You have described all of the machines in the plant, have you not, the air machines and the pyramid for the slimes and the other machines for the vanner concentrate?

A. The mechanical machine—we have another small machine there that we are treating a hundred tons per day with, using 20 pounds of oil to the ton, simply for experiment. It is called the K. K. machine.

Q. 82. What kind of a machine is that?

A. Well, it is a single unit within itself. I don't know hardly how to describe it. It is a rotary with baffles on a shaft enclosed in a sort of cylindrical housing. The feed goes into one end with the
3258 oil, and this rotary revolves approximately 180 revolutions a minute and it simply churns the feed and the oil and the air that it takes in at the intake, against the housing, and discharges it through round holes into a long spitzkasten, which is the length of the machine, and from this the concentrate is removed from the tailings and discharged at the opposite end of the machine from where it comes in. I have some cuts here of the machine, I have a drawing, but there is no flow sheet of this machine because it goes in at one end and out at the other, and the concentrates go out of the spitzkasten.

Q. 83. Those cuts that you have got, do they make its construction clear at all?

A. Well, not unless you really understand the machine. Here is the cut I have. I also have here a photograph of the machine in operation.

Mr. Scott: We offer the photograph in evidence.

Photograph admitted in evidence and marked Defendant's Exhibit No. 155.

Whereupon an adjournment was taken until 2:00 P. M. Saturday, April 28th, 1917.

Q. 84. This morning I asked you to compare in amounts of copper that would be recovered, by the figures prior to January, 1917, and afterwards, more than 20 lbs. of oil was being used. Will you state whether that figure that you gave, 17 lbs. of copper, expresses any real facts regarding the comparative merits of the two operations and if not how you would compare them.

3259 A. Well, in figuring the pounds of copper saved by extraction it does not mean anything to mill operation. We figure pounds of copper saved and the advantage or disadvantage of the process, in the amount of copper going to waste in the tailings per ton of ore. And, in comparing the year of 1916 with the year of 1917, the way we would compare it, on the pounds of copper going to waste in the tailings, you really must find the tonnage or the relative amount of tailings in comparison to the tons of ore treated, and I find on figuring by ratios of concentration, getting the tons of concentrate produced per ton of ore treated, and then getting the ton of tailings made per ton of ore treated. Taking your tonnage of tailings times your assay of your tailings, I find that when using for the year 1916, 3.36 lbs. of oil per ton we have practically the same

amount of copper going to waste in our tailings as we had during the year 1917 when we were operating with 20.1 lbs. of ore per ton.

Q. 85. Referring to the tabulation of the treatment of the slime vanner tailings, state whether or not the operations, the daily operations from February 8th to 28th were regular and constant or not.

A. Well, our daily operations on slime feed is practically normal at all times. That is, each hour of the day is practically the same as the preceding and the succeeding hours. We have immense storage facilities. The capacity of our plant consists of Dorr thick-
3260 ener, then we get our feed to the vanner and then to the flotation, is handled in such an immense quantity that there is, each hour during the day, they won't vary to any extent in feed. Now, during the period that you mentioned, the period from February 8th to 28th, when using 20 lbs. of oil or more in our slime feed, we treated on the 8th, starting out the operation, a very much smaller tonnage than the rest of the month would indicate. On this day we treated 180 tons. Then, for the succeeding days we averaged between 367, 336 and 378 tons per day, showing that our average was practically uniform, every day, every hour for every day in that month; and our oil consumed will average between 19.84 to 21.85 lbs. per ton for each day, showing that the average is practically normal at all times.

Q. 86. Now referring again to this tabulation of slime vanner tailings treatment, you say that the tonnage down to the end of 1916 is apparently greater than that after you began to use a large amount of oil. Now will you state why that is so?

A. In our slime treatment we found that we got best results when using crude coal tar and our tonnage was so great in this machine or on this product that we have been unable to date to secure a sufficient amount of coal tar to run our entire plant and so we just simply get enough oil to run at the times that we can, and we are endeavoring to collect as much of that coal tar as we can, and at the present time we have practically 100,000 gallons of coal tar which will throw the entire installation on a 1% or more of oil. In order to
3261 operate daily on our tonnage with 1% or more we would have to have approximately 14,000 gallons of coal tar a day or we would average about 140,000 lbs. or better than 3,000,000 lbs. per month. We have been unable, to date, to secure more than 50,000 gallons per month, so that we have to collect this oil and store it until we get enough to run five or six or possibly ten days on 1% or more. We have endeavored to get the coal tar from any source possible.

Cross-examination.

By Mr. Williams:

X Q. 87. What did you do in this slime vanner plant on the days between those that are given in 1917 in your table, exhibit 151?

A. We operated with our usual amount of oil, as we operated previously to this year.

X Q. 88. That is you say the smaller—that is to say you used the

smaller amounts of oil that you used before, in the days between when you have not got a large amount to use?

A. Yes.

X Q. 89. And you have not made any showing of those operations in your table?

A. No, I have not indicated that for the year 1917.

X Q. 90. You have described a pyramid plant, or a set of machines arranged in pyramid, a set of air machines, and represented
3262 them in a separate drawing. I suppose they are separate plants, are they?

A. They are separate plants.

X Q. 91. In none of these proceedings which you report here were they run together, is that right?

A. Yes they are arranged so they can be run together or run separately.

X Q. 92. Did you ever run them together?

A. We did.

X Q. 93. Do any operations appear in the reports where they were operated together?

A. The operations of January 17th and 18th, the operations of March 15th to 17th, and of March 20th to 26th.

X Q. 94. Have you described the manner in which they were connected up; possibly I have not followed you when you testified?

A. I have in this note below here, where I say that we recleaned twice; it simply means that we operated the pyramid as a roughing machine, and then recleaned by the air machine, which gives us a double recleaning.

X Q. 95. Now, when you use the air machines alone, what was the condition of the feed to the plant? You have noted here feed, and you have noted oils as going into the same place. Had there been any preliminary mixing of the ore and the oil?

A. There had not.

X Q. 96. So that in this instance you used this long series
3263 of air machines to perform the operation of mixing as well as aeration, is that right?

A. Well I will correct that statement to this effect. We did for a while send our feed and oil through the same emulsifier and then we sent our feed separately, and only our oil and water through this emulsifier, and the two combined just as they entered the machine.

X Q. 97. So that in that instance you had a pre-emulsification of the oil?

A. Yes.

X Q. 98. But it was pre-emulsified out of contact with the ore?

A. Yes.

X Q. 99. Did you maintain that as a standard operation?

A. Well, not during the entire. We would switch from one to the other.

X Q. 100. There were times when there was no pre-emulsification of the oils, and without any premixing or emulsification of the ore and oils you fed the oils separately and the ore separately into the air machine, is that right?

A. There were times when we did both.

X Q. 101. In the operation with smaller quantities of oil did you ever use the air machine alone?

A. You are speaking of the slime vanner tailings, are you?

X Q. 102. I understood that it was part of the slime plant?

3264 A. It is.

X Q. 103. Yes. If you ever used it in any way, just tell me; tell me what you know and then I will know what you know.

X Q. 104. Yes. You mean when we treated the slime vanner tailings in the air machine with small quantities of oil?

X Q. 105. Yes.

A. We did.

X Q. 106. In what manner was the oil and ore fed as to emulsification?

A. The ore and oil were emulsified before entering the machine.

X Q. 107. Emulsified together?

A. Yes.

X Q. 108. Can you tell me when you commenced to use this air machine?

A. I don't know whether I have the date on that or not. It was in the latter part of 1916. The result I have here showing the result of the air machine on small quantities of oil is of January 10th, 1917.

X Q. 109. That is the first entry that you have?

A. As a roughing machine, no; we used it in the latter part of 1916 as part of our cleaning system of our entire installation; I don't know just what date we put it in, but it was in the latter part of the year 1916 that we put it in.

X Q. 110. Did you put it in in the last month, in December?

A. Yes, I think it was in December.

3265 X Q. 111. I notice in your table "Flotation Operations treating slime vanner heading and slime vanner tailing," that the first period given is the second quarter of 1915, with the smaller tonnage than any succeeding quarter. That was the commencement of the operation of this plant?

A. Yes.

X Q. 112. And as the plant was then installed at the commencement of operation, in what respect did it differ from the plant that you have described?

A. At the commencement of operations the plant was a straight mechanical machine.

X Q. 113. Janney?

A. Yes. We did not have the pyramid installation then; it was five mechanical cells followed by five mechanical cells arranged in multiple. There was a feed going to each cell separately from the others, and the tailings combining and going to five cells separately. There were two lines of machines, five in each, in multiple, a straight mechanical machine. Then later on we installed the air basket.

X Q. 114. You had in this first plant your first set of machines and roughers, and your second set of machine cleaners?

A. We had the first set of five as roughers, followed by a second set

of five as roughers, and then followed by another set of five as cleaners. There were two sets of five in series as roughers, but the machines were arranged in multiple.

X Q. 115. What did you do then with the middlings from the cleaner machines?

3266 A. They circulated back to the head of the roughers.

X Q. 116. Give me the data for some one day's operation in that first quarter of 1915?

(Witness produces book.)

X Q. 117. Now, let us take June 15, 1915, please read off to me your record for that day, taking the numbers with the head of the column so that the number will be understandable.

A. 631 tons of heading, 549 tons of tailing, 15 tons of concentrate, 951 lbs. of No. 4 oil, 21 lbs. of pine oil; total 972 lbs. of oil.

X Q. 118. And what was No. 4 oil?

A. That is the Barrett's No. 4 creosote.

X Q. 119. Now, you might give me the average for the month of June or the smallest period that you have operated upon the amount of oil used per ton of ore treated.

A. Well, I will give you the average for the month of June, 1.91 lbs. of oil for the month of June, 1915.

X Q. 120. Now let us turn to July, 1915. Were the oils used the same during July as during June or was there a change?

A There was a partial change. I find that we used during the month of July some California fuel oil.

X Q. 121. In addition?

A. To Barrett's No. 4 and the pine oil.

X Q. 122. Now, read off the descriptive entries for July 15, 1915.

3267 A. Treated 1121 tons; 1081 tons tailings and 40 tons of concentrates; 1468 lbs. of No. 4 oil; 41 lbs. of pine oil: total 1509 lbs. of oil.

X Q. 123. Have you the assay of the heads, concentrates and tails of that day?

A. I have.

X Q. 124. Read them.

A. Headings, 1.13%.

X Q. 125. Copper?

A. Copper. 81.13% insoluble, 2.05% iron; tailings .535% copper; concentrates 17.3% copper; 31.33% insoluble; 10.9% iron.

X Q. 126. Now will you give me the similar assay for that day, June 15, 1915?

A. Heading 1.4% copper; 84.73% insoluble; 2.7% iron; .473% copper tailings; concentrates, 26.53% copper; 29.87% insoluble; 10.27% iron.

X Q. 127. Now, give me the average per ton of ore in the month of July, in this plant, 1915.

A. 2.01.

X Q. 128. Now, let us turn to the beginning of 1916. In January of 1916 had there been any change in the oil used?

A. I will have to look and see. In January, 1916, we were using Lewis tar acid and Jones oil.

X Q. 129. What is Lewis tar acid?

A. It is a creosote, coal tar creosote with, if I am not mistaken—This was a 30% tar acid content in the creosote.

3268 X Q. 130. And the Jones oil, is there any other name for that?

A. I have never heard it. It has the appearance of a crude oil.

X Q. 131. And these were the only two oils used during the month of January, 1916?

A. They were.

X Q. 132. Now, let us take the 15th of January, 1916, read off the record for that day.

A. 2261 tons treated in the head; 2226 tons tailings, 25 tons of concentrates; 2470 lbs. of Lewis tar acid; 823 lbs. Jones oil; 3293 total lbs.; 1.45 lbs. of oil per ton of material treated.

X Q. 133. Now, let us have the assays of that day.

A. .75% copper in heading; 91.80% insoluble, 1.6% iron; .506% copper in the tailings; 22.96% copper in concentrate; 24.93% insoluble in concentrate and 8% iron in concentrate.

X Q. 134. Now, I would like a typical individual day in among these operations during the present year when you used amounts of oil of 20 lbs. or more per ton. Take the run of February 8th to 28 in this same plant. Take the middle of the run, February 18th; please read off the record for the day.

A. 378 tons treated, 369 tons of tailings, 9 tons of concentrates, 7560 lbs. of coal tar, 20 lbs. of oil per ton of ore.

X Q. 135. That is very close, isn't it?

A. Some here go below and some above.

X Q. 136. Now, we will have the assay.

3269 A. .710% copper in headings, .393% copper in tailings; 13.06% copper in concentrates; 63.06% insoluble in the concentrates; 6.03% iron in concentrates.

X Q. 137. Now, we will take the record for February 11, 1917.

A. Treated, 463 tons headings; 456 tons tailings, 7 tons of concentrates; 85.68 lbs. of coal tar, 18.50 lbs. per ton of material treated.

X Q. 138. Now the assay.

A. .680% copper in headings; .455% copper in tailings; 14.46% copper in concentrates; 50.20% insoluble; 7.20% iron.

X Q. 139. Before I have this particular plant, what did you do with the material, what did you do with the kind and grade of material that you treated in this plant before you installed it?

A. This material was treated on our big permanent installation.

X Q. 140. Of what kind of concentration?

A. Flotation concentration.

X Q. 141. No; before you had flotation.

A. This material was going to waste.

X Q. 142. Not, in the other plant, for retreating the vanner concentrate products; is that right?

A. Yes, sir. This statement is wrong. We shipped this product to smelter.

X Q. 143. Your fourth quarter—Your table shows the fourth quarter of 1914 as the first entry. Will you let me have a daily record during that fourth quarter? Take the record of November 15, 1914.

3270 A. Treated, 207 tons of heading; 163 tons of tailings; 44 tons of concentrates; 624 lbs. of creosote, 212 lbs. of California fuel oil.

X Q. 144. And the total pounds of oil per ton of ore is then given for the day?

A. Yes, sir. 836 lbs. of total oil; used 4.34 lbs. of oil per ton of material treated.

X Q. 145. Now, the assays.

A. 7.23% copper in the heading; 73.80% insoluble; 7.13% iron; .563% copper in tailings; 4% iron in tailings; 31.87% copper in concentrates; 22.53% insoluble in concentrates; 16.93% iron in concentrates.

X Q. 146. Now, let us go to the first quarter of 1916 in that plant. Give me the figures for January 15th, 1916.

A. 250 tons heading, 201 tons tailing, 49 tons of concentrate, 487 lbs. of Lewis tar acid, 161 lbs. Jones oil, 40 lbs. Chesapeake pine, total 689 lbs. of oil; 2.76 lbs. of oil per ton.

X Q. 147. What is Chesapeake pine; pine oil or pine tar?

A. Pine oil.

X Q. 148. Now, the assay.

A. 5.4% copper in headings; 73.6% insoluble; 6.9% iron; .40% copper in tailings; 26.1% copper in concentrates; 60.9% insoluble; 21.2% iron.

X Q. 149. Now, let us look at some of the operations in 1917 with larger quantities of oil. Were these operations continuous from their commencement?

A. Yes, sir.

3271 X Q. 150. Give me the record for January 8th, 1917.

A. Treated, 300 tons headings, 240 tons tailings, 60 tons concentrates, 5432 lbs. California fuel oil; 603 lbs. Barrett No. 4 creosote; total 6035 lbs. of oil, or 20.11 lbs. of oil per ton.

X Q. 151. Now, the assays?

A. 5.3 per cent copper in heading, 77.4 per cent insoluble, 6.2 per cent iron. 4.96 per cent copper in tailings, 24.50 per cent copper in concentrate, 28.3 insoluble in concentrate and 18.16 per cent iron.

X Q. 152. Now give me the record for January 9th, 1917?

A. Treated 300 tons, 238 tons tailings, 62 tons concentrate; 5342 pounds of California fuel oil, 297 pounds pine oil, 297 pounds Barrett No. 4; total oil 5936 or 19.78 pounds of oil to the ton of material treated.

X Q. 153. Now, the assays?

A. 5.7 copper in the heading, 76% insoluble, 6.2 per cent iron. .583 per cent copper in the tailings, 25.2 per cent copper in the concentrate, 29.23 per cent insoluble, 17.13 per cent iron.

X Q. 154. Now, let me look at the report for February, 1917. Give me the report of February 24th, 1917?

A. 300 tons of heading, 204 tons of tailing, 96 tons concentrate.

4471 pounds California fuel oil, 497 pounds Barrett No. 4, total 4968 pounds of oil, or 16.56 pounds of oil per ton.

3272 X Q. 155. Now, the assays?

A. 8 per cent copper in the heading, 71 per cent insoluble, 8.2 per cent iron. .380 per cent copper in the tailing, 24.26 per cent copper in the concentrate, 27.36 insoluble, 19.2 per cent iron.

X Q. 156. In these figures that you have given me of the assays, has there been an inclusion of a copper oxide?

A. Yes.

X Q. 157. In the tailings?

A. Yes.

X Q. 158. And did your tables show the amount of oxide, or was that separately assayed.

A. The assay indicated in the table takes into account the amount of oxide in the product.

X Q. 159. Does it include it or exclude it?

A. The assay includes the oxide.

X Q. 160. So that the tailing is actually composed of so much metallic copper and so much oxidized copper, and they are both counted together in the assay?

A. Yes.

X Q. 161. How large a factor would that be in the operations, the amount of oxidized copper that goes in the tailings?

A. Well, it is greater than fifty per cent of the copper in the tailings; for instance, if you have four-tenths of one per cent copper in the tailings, .28 will be in the form of oxide and .12 in the form of sulphide.

3273 X Q. 162. And that is a fairly uniform average is it?

A. Yes.

X Q. 163. My attention is called to the fact that I said metallic copper when I should have said copper sulphide. You understood me to mean copper sulphide?

A. Yes, that was just a mistake.

X Q. 164. Now, in your operations have you used anything else than oil, ore and water?

A. That is, any other chemicals?

X Q. 165. Yes.

A. We have not.

X Q. 166. Or acid?

A. No acid.

X Q. 167. And no other reagent?

A. The only thing that is in the ore is, they add lime at the mine, simply to protect their screens and rolls at the head of the mill, but that is not done for any flotation purpose, because we can get very much better results without the lime than with the lime.

X Q. 168. That is, the ore as it is dug out of the ground is a little acid?

A. Yes.

X Q. 169. You put in lime to neutralize that?

A. Yes.

X Q. 170. And is that true of your operations since the first of the year as well as before?

A. Well, we ran into the acid ore about the middle of 1916, about the middle of the year, and it has been continuous ever since.

3274 X Q. 171. The acid?

A. Yes.

X Q. 172. That is sulphuric acid of course?

A. Yes.

X Q. 173. Do you ever heat your pulps?

A. No, sir; we have never tried heat.

X Q. 174. Now, I wish you would describe for the court what an operator does when he is controlling the operations of a flotation plant? Let us go back to the time when you used the small amount of oil. Of course you understand just how it is done, and I would like you to tell what the operator does, what is it that controls him in his regulation of the plant?

A. He pays very close attention to the amount of oil he is adding. He can tell by the appearance of his machine whether he is adding a sufficient amount of oil to maintain good results.

X Q. 175. By the appearance of the froth in the machine?

A. By the appearance of the froth in the machine and the way the machine is acting. He inspects his elevators every so often, to be sure that there is no slippage and that the feed is coming to the plant steadily, and tries to maintain normal operating conditions at all times. He will go over his machine and determine whether he has sufficient air to produce a concentrate whereby on the recleaner he will maintain the grade that we would like to have maintained in our plant, and any irregularities that happen in

3275 the plant, why he is so trained that he knows exactly what to do and where to go in order to counterbalance this fluctuation of operation.

X Q. 176. I suppose the appearance of the froth is one of the important indications when anything needs attention, is it not?

A. The appearance of the froth, as well as the discharge of the froth.

X Q. 177. That is the amount?

A. The amount.

X Q. 178. The amount of the overflow?

A. Yes.

X Q. 179. In these machines of yours do you have a natural overflow or do you help it along with a paddle?

A. No, in these machines we have no mechanical froth removers at all.

X Q. 180. The froth just overflows by gravity?

A. Yes, in this slime treatment. In treating the concentrate we have mechanical removers. The froth is much heavier and more compact, but we don't have the mechanical removers on the series cells of the cleaning machine. We have at the multiple machines where we make the finished concentrate, but the slime treatment we have no mechanical removers.

X Q. 181. What are the conditions in the appearance of the plant by which the operators are told to reduce the oil supply?

A. In operating, if the appearance of the froth is sort of—
3276 our slime is yellow slime, and if the appearance of the froth is too yellow, he comes to the conclusion that he is discharging more insoluble or a lower grade of froth than he really should, and you can either cut down or diminish the air to a certain extent, or you can cut down your oil, and when the operation is normal or practically so, you can maintain about the same results at that point. Cut down your agitation or cut down your oil.

X Q. 182. Can you give me separately the oxides and the sulphide copper assays of the heads and tails for the year 1916?

A. I think I can.

X Q. 183. Will you do that?

A. Yes, sir. I cannot give you the heads; I can give you the tailings. On treating slimes, the per cent of oxidized copper in the tailings will average for the year 1916 .20. On retreating the concentrate, the oxidized copper in the tailing for the year 1916 will average .18.

X Q. 184. Now, have you got it for the first quarter of the year 1917?

A. I can give it to you by the month.

X Q. 185. All right, give it for each month separately.

A. For the month of January, 1917, the percentage of oxidized copper in the slime tailing was .276, and for January, 1917, the percentage oxidized copper in the tailings for retreating concentrate was .214. For the month of February, 1917, per cent oxi-
3277 dized copper in the heads for February, 1917, on our slimes was .311; percentage of oxidized copper in tails for slimes during month of February was .266; percentage oxidized copper in concentrates, retreating concentrates, was .19.

X Q. 186. Now, these figures in the slimes plant have been both the operations with amounts of ore exceeding 20 lbs. and operations with amounts of oil less than 20 lbs. per ton of ore, have they not?

A. Yes. This statement is made up of the total slimes treated regardless of the amount of oil used.

X Q. 187. Now, what arrangement does your company have for the selling of concentrates?

A. We have a flat rate with the smelter. If I am not mistaken, it is $5.00 per ton of concentrates regardless of per cent. of copper, insoluble or iron; we are not penalized for insoluble and we are not penalized for iron.

X Q. 188. And where are your concentrates smelted?

A. In the town of Hayden, about a quarter of a mile from the concentrator.

X Q. 189. What is the name of the smelter?

A. It is the American Smelting & Refining Company.

X Q. 190. Now, in regard to your contract, isn't that affected by the price of copper?

A. No, I think not. We have a flat rate of so much per ton of concentrate.

3278 X Q. 191. Do you know that as a fact, or is it just a matter of information?

A. No, I don't know that as a fact. I haven't seen the contract, but that is my understanding.

Mr. Williams: We have still of course to have the operations such as have occurred since the first of the year connected up with the prior art, and with that reservation for the completion of that testimony, I close the cross-examination at the present time.

Redirect examination.

By Mr. Scott:

R. Q. 192. What is that $5.00 you mention; is that a smelting charge?

A. That is a smelting charge per ton of concentrate, that they charged the Ray Consolidated Copper Company.

R. Q. 193. How about the amount of attention and adjustment the flotation apparatus requires when, say 20 lbs. or more of oil are being used per ton as compared with when using three or four pounds?

A. They make no change in the operation at all.

R. Q. 194. I meant the amount of attention it requires from the attendant.

A. It requires no more attention to operate with 21 pounds than it does to operate with three-quarters of a pound.

R. Q. 195. I think you found a cut of that K & K machine this noon?

A. Yes, sir, I have a cut of the machine.

3279 R. Q. 196. I wish you would briefly explain the operation of that machine and put any letters on you need to, to tell what these two pictures are you have.

A. "A" will represent the intake for feed and oil. "B" represents tailings to waste. "C" represents concentrates discharged. "D" represents the shaft on which this baffle spindle is connected which revolves at the rate of 180 revolutions per minute. "E" will represent automatic operating float discharge. "F" will represent housing surrounding the rotator which is composed of baffles.

R. Q. 197. Can you explain the operation better from the cross section?

A. On the cross section view "A" will represent the rotator which is built up of baffles. The feed comes into the machine at one end and the centrifugal force of this rotary, which is 180 r. p. m., draws the feed and the oil and discharges it against the inside of this housing.

R. Q. 198. Where is the pulp in the machine before it is picked up by the rotary?

A. Well, it comes right in at one end of the rotary. The rotary is entirely the machine.

R. Q. 199. Just make a mark to show where this pulp is thrown.

A. The pulp would hit in right by the letter "B".

R. Q. 200. Now, place a letter where the pulp is picked up by that rotary.

A. The pulp is picked up at the letter "C".

3280 R. Q. 201. And then it is whirled around in this upright space between the rotary and the housing?

A. Yes, sir.

R. Q. 202. Then put a letter where it is discharged.

A. Discharged at letter "D".

R. Q. 203. Where does the air come from that makes the bubbles for the froth?

A. The air comes—goes in with the feed at the intake and also at the end, with the shaft, supported by the bearings. The air goes in at both places. There is suction on both ends of the machine and suction at the intake of the machine; three places where the air can enter the machine.

R. Q. 204. Are these placed apart, these what you call baffles, or slats, whatever they are?

A. Yes, about a quarter of an inch apart.

R. Q. 205. Do I understand that the air is drawn out through there, and this narrow sheet of pulp?

A. No, you understand the air is taken in at the ends and entered into the machine at the same point that the feed enters, and this inside of this rotary, there is chance for the feed to get inside of there, too, through these places where the bearing is.

R. Q. 206. You said the pulp progressed through the machine; what is its movement, its course?

A. It would progress similar to a curve.

R. Q. 207. You mean it goes around through the rotary more than once?

A. In starting the machine without any oil at all, and putting your oil in, the froth will first form at the head, and then it

3281 will work slowly down to the tailings.

Mr. Williams:

R. Q. 208. You have this rotating device as a long cylinder extending the length of the machine and rotating at the speed you have stated? Is that right?

A. Yes, sir.

R. Q. 209. This cylinder has an outer surface composed of what you call baffles which appear to be supported by slats; is that right?

A. Yes.

R. Q. 210. Now, outside of these baffles there seem to be some similar contrivances; what are they?

A. Those are baffles.

R. Q. 211. Those are real baffles?

A. Those are real baffles. This is just the timber to attach the baffles to.

R. Q. 212. So that these baffles are practically a series of slats extending over the outside of this rotating cylinder?

A. Similar to the riffles on a Wilfley Table.

R. Q. 213. And what is the over-all length of the machine, about?
A. It is 14 feet long and about 4 feet high.
R. Q. 214. And about what is the diameter of that rotating cylinder inside?
A. As close as I can estimate it is about two feet; probably a little larger.
R. Q. 215. No, if it is four feet high, if the machine is four feet high——
A. (Interrupting.) 32 inches they have there, to be exact.
3282 It is 32 inches—that of course takes in the base and the housing.
R. Q. 216. The over-all height of the machine is given here as 32 inches. It can be readily computed.
A. I don't know what the exact dimensions are, but that housing is only about an inch and a half timbers.
R. Q. 217. The inside of the housing is smooth?
A. Yes, sir.
R. Q. 218. And it is a complete water tight housing?
A. Yes, sir.
R. Q. 219. I don't remember just what you said about the use of this machine. Is it—what is it used now in your plant for?
A. We are using that machine to test different kinds of oils now, and we did use it as a test on some small quantity of oil, and with large quantity of oil just a comparative test of the two.
R. Q. 220. And you found it worked pretty well with either?
A. Equally as good with the large percentage of oil as it does with the small percentage.

Mr. Scott: I offer this illustration, one of them on the large sheet entitled "K & K Flotation Machine" the other the small folder entitled "K & K Flotation Machine Bulletin No. 1".

The documents were admitted in evidence and marked Defendant's Exhibits 156 and 157.

(Witness excused.)

3283 BEN H. DOSENBACH, recalled for further direct examination by Mr. Scott having been previously sworn testified as follows:

Direct examination.

By Mr. Scott:

Q. 1. You are familiar, are you, with the Everson patent?
A. I am.
Q. 2. Have you ever attempted to carry out the process described therein?
A. I have.
Q. 3. What apparatus have you used for carrying out this process described in the Everson patent?
A. One form of apparatus that I have used is an apparatus that is built according to the Fryer Hill publication.

Q. 4. That publication that is in evidence?
A. That publication that is in evidence in this case.
Q. 5. Have you the machine here?
A. I have.
Q. 6. Will you refer to the Fryer Hill publication and compare the description therein contained with the machine itself?
A. With reference to the Fryer Hill publication, the "Daily Herald Democrat," Leadville, October 30th, 1889. This is a publication which refers to a certain method of concentrating ores with the use of oil, and in that description a machine or apparatus
3284 is described. This publication states that "The whole system of concentration appears to be based on the well known affinity of the lighter forms of sulphuret and chloride of silver for oils. Petroleum is the oil now being used by the parties having these experiments in charge and appears, from its density, to possess the requisite adhesiveness to effect the results desired." It says that "The ore is first crushed and rolled to such a degree of fineness as to enable it to pass through a 40 mesh screen and while dry, is thoroughly mixed with the oil, after which it is placed in a circular tank or receiver."
Q. 7. What are you reading, Mr. Dosenbach; the Fryer Hill publication?
A. Yes.
Q. 8. Unless you have some comment to make on some part of it it won't be necessary to read it.
A. Well, I was just coming to the description of the machine in this publication and I will follow it up by referring to the machine itself, which I have now in court and also to a drawing which represents the machine. The ore is thoroughly mixed with the oil "after which it is placed in a circular tank or receiver." This is the circular tank or receiver that will be used in the experiment which is illustrated in this drawing by the circular tank or receiver.

Mr. Williams: I just want to call attention to the fact that the witness said "The ore is thoroughly mixed with oil" omitting
3285 two lines of the description, one part of which says that the ore is crushed so as to pass through a 40 mesh screen.
The Witness: I have read that, Mr. Williams, begging your pardon.
Mr. Scott: If you wish to, you can point out on the machine as you read it.
A. "Through the center of which runs a rotating hollow tube," which is this rotating hollow tube in the drawing and this rotating hollow tube on the machine itself. "To the bottom of which tube is attached, on two opposite sides, a couple of fans," which are these fans at the bottom of the hollow rotating tube as shown in the picture, these two rotating fans,—"the lower edges of which are unevenly cut in order to send—in the revolutions—the lighter particles of the ore and oil mixture to the outer sides of the drum or cylinder." That is these lower edges of the fans which are unevenly cut, so as to give an upward motion to the agitated material, which is shown

on the machine itself, are unevenly cut, the lower edges of the fan. "This rotating hollow tube is perforated at, or near, the bottom," which shows several small perforations at or near the bottom, just small holes, just above the fans, "and, when the receiver is thoroughly charged, acidulated (sulphuric acid is used). Steam is introduced through the tube and is forced to the bottom of the mixture while the arrastralike fans, attached to the bottom of the tube, keep the whole mixture in motion, and, the action of the revolving
3286 tube, the fan, and injected acidulated steam causes the lighter portions of the mineral-charged oil to float to a point just above the center of the receiver, where there are suspended two semi-circular doors, when the oil has passed above them, laden with its precious freight, are raised, and the superfluous water allowed to drain through slight perforations in the bottom of these semi-circular doors, after which the mineral-laden oil is carefully removed to settling barrels revolving with jets of steam injected continuously from the lower end." Well, the rest of that we needn't show, because that is an after treatment to recover the metal. These doors, however, are perforated, as shown in the machine itself, and also in the drawing which I have here. This shows the shaft and the semi-circular doors raised, and this shows them when they are lowered after agitation. The mineral froth rises to the surface above the doors and the doors are closed, and as the description says, "in order to recover the metal."

Q. 9. Now, will you state what ore you are going to use and how you are going to proceed in carrying out the experiment or demonstration?

A. In the experiment that I am about to perform according to the Everson patent and also the Fryer Hill publication, I will use Utah Copper ore, or the retreatment classifier overflow from the Utah Copper Plant.

Q. 10. What quantity of oil are you going to use?

A. I will use 300 gms. of this ore and to it I will add 51
3287 gms. of a petroleum distillate. After adding the 51 gms. of petroleum distillate I will thoroughly mix the dry ore and the oil, making a homogeneous mass of the oil and ore. This will then be placed into the receiver of the machine, and I will then add 1,250 cc. of water. The machine will then be started, and as I cannot use any steam or acidulated steam, I will use hot water containing sulphuric acid, to correspond to the acidulated steam which is mentioned in the Fryer Hill publication. The agitation will be continued for possibly two or three minutes. I will perform the experiment, and after having performed the experiment, will give a complete description of the operation.

(Whereupon a short recess was taken.)

(Test No. 30.)

The Witness: Now, if you would like to have a sample of that ore that we are going to use in the experiment, you can have it.

Mr. Williams: Very well, we will take it.

Q. 11. You might state, while we are waiting, whether or not you are going to use the forty mesh material described in the Fryer Hill publication?

A. I am going to use material that is through a forty mesh screen, yes, sir.

Q. 12. You are metallurgist enough to know that what you have said may have several meanings. Is this forty mesh?

3288 A. It will all pass a forty mesh. There will be approximately two or three per cent of it on a sixty-five mesh, which is slightly finer than a forty mesh screen, and ranging from there on up to the finest size, which is minus 280 mesh.

Q. 13. That is to say this is a product containing a great amount of slime?

A. It is a product which contains about 60% minus 200 I should say. As I remember—and I will refer to the publication—the publication states the ore is first crushed and rolled to such a degree of fineness as to enable it to pass through a forty mesh screen.

The Court:

Q 14. Well, are you ready for this experiment?

A. Yes, sir. They have been sampling the ore, so as to give the other side half of the same material that I am going to use, and that has consumed considerable time.

I will now add oil, 51 gms., to the dry ore, and thoroughly mix the oil and the ore until a homogeneous mass of oil and ore is formed.

The Court:

Q. 15. You have what weight of oil and ore there?

A. I have 51 gms. of oil to 300 gms. of ore, which makes 17 per cent of oil relative to ore.

Mr. Scott:

Q. 16. Where do you get that proportion of oil to ore; what is it based on?

A. That is taken from the Everson patent, the figures as used in the Everson patent being reduced to the proportions that I now use.

The oil and ore is now thoroughly mixed. I will now add

3289 1,250 cc. of water, having a temperature of 42° C. I have now added 2.4 cc. of sulphuric acid to 50 cubic centimeters of hot water, which I will add after starting the machine. (Machine started.)

Mr. Williams:

Q. 17. At what speed is that arrastra revolving?

A. I don't know what you mean by arrastra?

Q. 18. Well, the agitator that you have there, how fast does that revolve?

A. I will tell you in just a minute; I have it marked so I can tell when the machine stops.

(Machine stopped.)

Mr. Scott:

Q. 19. How would you describe that float as to its structure and what it is made up of?

A. I would describe that float to be a mineral froth consisting of copper sulphide mineral, air bubbles, which can be seen very distinctly by observing from the top, and naturally there is present around those air bubbles some oil. That froth I take to be something over an inch thick; about an inch and a quarter in places, and an inch in places, or an average of about an inch and an eighth. The differentiation from the tailings is a very noticeable difference, showing that there has been quite a concentration.

Q. 20. Will you compare this operation which you have just performed with the course of proceeding in actual concentration in a mill?

3290 A. It is very similar to the actual procedure in a mill, with the exception that in a mill there are a number of these same operations carried on in series, whereby the tailings resulting from this one particular operation would be retreated in another vessel of the same character as this one. There may be a great number of them, anywhere from 5 to 14, or possibly more or less, and this constitutes a part of the operation.

Q. 21. The first step, as it were?

A. The first step I should say. The tailing is settling very rapidly now, showing comparatively clear water between the tailings at the bottom of the solution or the vessel and the froth upon the surface.

Q. 22. In actual operation is it customary to make a final tailing with one operation of this kind?

A. It is not. They continue the operation and recover additional froth and mineral in a froth from the tailing that we now see in the bottom of the cylinder.

Q. 23. Is there any way in which you can get a sample of that concentrate there for analysis?

A. Why, yes, I can get a sample of the concentrate for analysis, showing the degree of concentration, that is, the amount of valuable mineral that is contained in the froth as compared to the original ore with which I started.

Q. 24. In that particular apparatus is there any way of getting all of that froth off, so you could determine the total amount of mineral that is in it?

3291 A. There is no possible way of recovering all of the froth in this apparatus, as the apparatus itself is merely to show the purpose that it was built for, and not for metallurgical recoveries; but a sample of the froth can be obtained and analyzed to show the extent of the concentration.

Q. 25. Will you do that now?

A. I can do that, or I can have it done and go ahead.

Q. 26. Well, it might save time if you have some one from each side do that?

A. That would simplify matters to have a representative from

the other side assist one of the men from this side, and mutually agree as to the sample of the concentrate.

Mr. Williams:

Q. 27. Those doors which acted as baffles in that agitating operation, what use are you going to make of them now?

A. I will spread the doors out, as stated in the publication, and recover as much of the concentrate as possible, so that analysis can be made of the product, and I will do that myself so that it can be seen just how they work. Now, I have closed the doors, as it were.

Mr. Scott:

Q. 28. Raised them to a horizontal position.

A. Raised them to a horizontal position.

Q. 29. And they are down here below the froth as the court can see; they were hanging vertical, and you have opened them out?

3292 A. Yes. Now, the jar will be lowered, and the concentrate froth will rest upon the doors.

Q. 30. Instead of raising the doors in this machine, you simply lower the jar?

A. Yes.

Mr. Williams:

Q. 31. You did not give me the speed yet at which it turned?

A. Yes, I will give you that speed. It was between 1,400 and 1,500 revolutions per minute. Now, if one of the representatives from the other side is present and can assist in the operation we might go ahead, or watch the procedure.

Mr. Scott:

Q. 32. I would like the court to see how you get that off; it will only take a minute. You might state how efficient that method of getting that froth is?

A. It is a very inefficient and crude method of recovering the froth, but it shows the nature of it.

Q. 33. Where is the jar; you cannot get it all?

A. No, I cannot possibly recover all of it.

A. Now, I would like to state further that it can be readily seen that when lowering the jar and recovering the metal upon the cylindrical doors, that some of the mineral has fallen down to the bottom of the vessel and rests down in the tailings. There is quite a noticeable difference between the mineral which has fallen and the gangue material which are at the bottom, the mineral being very dark in color, lying in a stratum above the tailings; the tail-

3293 ings being very much lighter in color than the original ore, and decidedly so, as compared to the mineral in the froth.

Q. 34. Was there any dark mineral on top of the tailings, in the bottom, before you performed your operation with the doors?

A. There was not, and that was my reason for wishing to show it at this time.

Q. 35. Now, the other day Dr. Sadtler testified regarding the cataract machine described and illustrated in a German book which he produced. Have you had a machine made in accordance with that description?

A. I have.

Q. 36. Have you the machine here?

A. I have and I will bring it forth. If you will pardon me, I would like to state definitely what I used in that experiment, so that it may be upon the record. In the experiment that I have just completed, following the Everson process in the Fryer Hill machine I used 300 grams of Utah Copper retreatment classifier overflow containing approximately 7.9% copper, 5.36% iron and 77% insoluble. To this ore I added 51 grams of a petroleum distillate and thoroughly mixed the two until a homogeneous mass was formed. This oiled ore was placed into the cylinder of the machine and 1,250 cc. of water added at a temperature of 40° C.; the machine was then started up and 2.4 cc. of sulphuric acid and 50 cc. of hot water was added and the agitation continued for a period of 2½ minutes. Upon stopping agitation a mineral froth formed
3294 above the semi-circular doors, being about 1⅛ inches in thickness. After allowing the gangue material or tailings to settle to the bottom of the cylinder so that the solution was comparatively clear between the froth and the gangue I opened the semi-circular doors so as to spread them out horizontally and then lowered the cylinder, leaving a portion of the mineral froth resting upon these doors. The mineral froth that remained on the doors was then removed from the doors and the contents will be reported later.

Q. 37. I hand you the book that Dr. Sadtler referred to by Louis Andes and ask you if that is the illustration following which you had the machine constructed.

A. This is the illustration from which the machine that I will now present has been constructed.

Q. 38. Did you read it or have someone translate the descriptive part of the book for you?

A. Dr. Sadtler has translated the descriptive part of this book. It is in German and I am not very good at that.

Q. 39. Will you produce the machine?

(Witness produces the machine.)

Mr. Scott: I might state for the information of the court that this publication following which that machine was built has been referred to by witnesses as describing an operation under the Everson patent and this is how we followed that. Now, this apparatus which Mr. Dosenbach has now was built after this publication,
3295 which was some years before the date of the Everson patent, the purpose merely being to use an apparatus that was known at that time.

Mr. Williams: And this apparatus was an oil purifier, oil purifying machine, so described, was it not?

Mr. Scott: If you want to testify you may do so, or have me.

Mr. Williams: Well, if your honor please, I object to wasting the time of the court by carrying on experiments in an oil purifying machine for the purpose of showing an operation of ore concentration; as wholly incompetent, irrelevant and immaterial.

The Court: What is the purpose of this?

Mr. Scott: The Everson patent described the agitation, the thorough agitation of the mass, and this agitator is simply taken from the technical literature.

The Court: You simply want to show that there were appliances that would agitate?

Mr. Scott: And by performing this operation that would bring about the type of agitation suitable for the purpose of the patented process.

The Court: There is no question at all that at that time the world was full of agitating apparatus; every farmer's kitchen and yard had them, as far as that goes.

Mr. Scott: The point was very strenuously made in the other trials that the record showed no agitating apparatus that was
3296 capable of accomplishing the purpose, and great stress was made of it in the argument. I thought myself it was rather a far fetched point; and, being made and advanced seriously why we considered that we must meet it.

The Court: Well, how many more like it have you?

Mr. Scott: Well, we will illustrate the Kirby patent.

The Court: No, I mean of these appliances that you want to show that were capable of agitation?

Mr. Scott: This is the only one.

The Court: Let the record show what it is and the objection will be overruled. I believe the doctor already testified that this was an oil purifying machine.

Mr. Scott: Yes, it is in the book; that is in the record and it has been referred to as an agitation apparatus. I think that is the point they laid emphasis upon.

Q. 40. Now, Mr. Dosenbach, have you found it possible to carry the Everson procedure on this apparatus?

A. I have found it possible to carry out the Everson procedure in the apparatus as set forth in that book described by Dr. Sadtler.

Q. 41. This is the same apparatus regarding which Dr. Sadtler's remarks appear on page 740?

A. It is the same apparatus as testified to by Dr. Sadtler.

3297 Q. 42. That built under your direction?

A. This was built under my direction.

Q. 43. And in proportion and form does it conform to the description in the German book you referred to?

A. It does with the exception that I had this glass cylinder put on here so as to see the result and the froth, and the proportions are very similar. There are baffles as stated—as shown in this illustration which are also in the machine and can be noted. This is a cross section and the baffles run around the whole circumference, inside directly above these two fans or arms which are shown in the

bottom of the illustration. Directly above the baffles and on the shaft is shown another—a disk, which is this—I am pointing out now, and I take it from the illustration that the disk revolves with the shaft.

Q. 44. Now, will you state about what ore and the proportion you are going to use in illustrating the Everson process on this cataract apparatus?

A. I will use a material that is very similar to the one that I used in illustrating the previous Everson experiment. It is a Utah copper ore or a material called Utah copper retreatment classifier overflow.

Q. 45. That is what the other was?

A. That is what the other was. It is similar material.

Q. 46. Now, if you will proceed?

(Witness performed experiment No. 31.)

3298 A. I now have thoroughly mixed the ore and the oil.

Q. 47. How does the froth which you have formed in this cataract machine compare with the one which you made in the Fryer Hill machine?

A. They appear very similar in character. The froth formed in this machine is highly mineralized, consisting of copper sulphide, mineral and air bubbles. They seem to be very much the same in richness. However, the froth is a little thicker, it appears to be so, in this experiment as compared to the previous experiment in the Fryer Hill publication.

Q. 48. Was there more mineral in this or the other one?

A. There possibly might be. The amounts are very close.

Q. 49. What was the assay of the material used in the Fryer Hill machine?

A. An assay of the material treated in the Fryer Hill machine was 7.9 per cent copper, and in this machine I have it to be 6.18 per cent copper. There was a little more iron in the ore that I used in this experiment than in the one that I used in the previous experiment. The iron in the ore as used in this experiment was 6.69 per cent as against 5.36 per cent in the Fryer Hill experiment.

Q. 50. When you said this froth was thicker you meant it was of greater depth?

A. Greater volume and height.

3299 Q. 51. You didn't mean the consistency of the froth?

A. Absolutely not, because it will be readily seen the individual bubbles that are shown on the sides and also on the surface.

Q. 52. Did you give all the details of this experiment?

A. I have not given all the details but I will do so. During the process of the operation I took the speed, and it will be necessary to count this ratio before I can give it. The speed of agitation was 724 revolutions per minute.

Q. 53. And how long was it agitated?

A. Two minutes and a half. I give the proportions as used in the experiment.

In the experiment just completed, following out the Everson patent in the so-called cataract machine I used 200 gms. of Utah copper

retreatment classifier overflow, containing about 6.18 per cent copper, 6.69 per cent iron and 76.2 per cent insoluble. I added to this 200 grammes of ore, 34 gms. of Texas petroleum distillate, and thoroughly mixed the two to form a homogeneous mass. Having placed this oiled ore in the machine, I added 1250 cc. of water at a temperature of 30° C. I next started the machine, and directly after starting the agitator I added 50 cc. of hot water containing 1.6 cc. of concentrated sulphuric acid. The agitation was continued for two minutes and a half at about 720 revolutions per minute. The
3300 result upon stopping the agitator was that a very highly mineralized froth appeared on the surface of the pulp.

Q. 54. Are you going to remove a sample of that froth resulting in this experiment?

A. I think it would be advisable to remove a sample of the froth and furnish a duplicate sample to complainants.

Q. 55. Have you the material here this afternoon to perform a demonstration illustrating the California Journal of Technology article? If not, we will put it off?

A. I haven't it down here, no.

Q. 56. Well, we will go on with something that is here.

The Court:

Q. 57. Let the court understand—these two experiments represent the Everson process?

Mr. Scott: The specific quantity of oil and the amount of—and the kind of the oil.

Q. 58. Now, could you this afternoon demonstrate the Kirby process with 25% of oil?

A. I can.

Q. 59. Suppose you do that, then? Describe what you are going to do, if you wish to first?

A. I would suggest that a representative of the other side here assist in removing some of the froth that appears in the cataract machine.

I will perform an experiment using 25% of kerosene dis-
3301 tillate, which is a thin distillate hydro-carbon, on some of the same material—a sample of the same material that I have used in the two Everson experiments. In the experiment that I am about to perform, illustrating the Kirby patent, I will use 300 gms. of Utah copper retreatment classifier overflow, the assay of which is about 6.15 per cent copper, 6.6 iron, and 76.2 per cent insoluble. I will use 1500 cc. of water at a temperature of about 25° C., and 2 cc. of concentrated sulphuric acid. The oil which I will use is kerosene or petroleum distillate, and I will use 92 cc. of this oil, which is equivalent to 75 gms. or 25 per cent of oil relative to ore.

Mr. Williams:

Q. 60. Where is the Kirby machine?

A. I am performing the demonstration in the agitating glass jar machine.

Mr. Williams: I object to that, and call your honor's attention to the fact that the Kirby patent shows a complete and elaborate apparatus capable of reproduction, and of which we have made a reproduction, and of course you can only understand what a patentee means by doing the thing as he did it. Now, this is an attempt to repeat the operation which takes place in that complicated machine, in a square glass jar, just as it was done in the Supreme Court of the United States and in Wilmington, Delaware, by these plaintiffs, and it seems to me that it is a waste of the time of the court to repeat

3302 in a glass jar, with terrific agitation, an operation which obviously could not have taken place under such conditions, and that the only operation that will be in the slightest degree relevant and material to this case will be an operation carried on in the Kirby machine. I will ask your honor to look at this machine, consisting of two vessels, an agitator and a separator, with all the details shown in the drawings.

In the next drawing is shown the separator, and there are still further drawings; a carefully devised apparatus, and here we have a glass jar with a rotating stirrer.

The Court: Well, now, I am a little doubtful of the value of some of these experiments myself, but, circumstances, of course, will be taken into consideration by the court in weighing the evidence. For instance, now, in the last two experiments which you say illustrate the Everson process, where do you get that agitation in the Everson process?

Mr. Scott: The Everson patent says the mixture is thoroughly agitated. Now, the patent in suit has no stronger language than that on the subject of agitation.

The Court: Well, we will allow it to proceed for the purpose of the record. The objection will be overruled, and, as the court said, the circumstances, of course, will be considered. Really what you will do now, you might as well say, would be the process of the patent in suit with 25% of oil, wouldn't it?

Mr. Scott: Absolutely; that is exactly what it is. The Kirby

3303 patent recommends that quantity of oil, and has really stronger language on the subject of agitation than the patent in suit. A process patent, as the Kirby patent is, is merely required to illustrate some apparatus capable of carrying out the process; the process is in no way related to the apparatus. This can be done in anything, a glass jar or with an egg beater, or any apparatus. So why build a complicated structure like Kirby had when the object is simply to show that agitation will produce the result.

The Court: Objection overruled.

Plaintiff excepted.

(Test No. 32.)

The Witness: I am now adding the acid after having added the ore and the water in the glass jar. I will next add 92 cc. of distillate.

(Machine started and run for some time.)

Q. 61. What result have you in this experiment, Mr. Dosenbach?

A. A very copious, highly mineralized froth is formed.

Q. 62. Are there any more details as to that experiment, or did you say everything you wanted to before you started it?

A. I gave the quantities used, and so forth, before starting the experiment. The only thing that remains is the agitation, which was for a period of three minutes at approximately 1600 revolutions per minute.

Q. 63. Have you prepared an experiment in which you make a froth and sinking granules with the same amount of oil?

3304 A. Yes, but I haven't time to complete the experiment this evening as it takes ten to twelve minutes to continue the experiment alone, much less get it ready.

Q. 64. You might describe it; it won't take but a little time to describe it and use the time up, so that we will get it in the record.

A. Yes, I can do that. I have performed an experiment and can repeat the same, using the cone Gabbett——

Mr. Scott: I would like the record to show that samples of the froth in this last experiment as well as in the others, have been furnished to representatives of the plaintiff.

The Witness (continuing): The experiment that I am speaking of was performed in the cone Gabbett machine on Butte & Superior ore using oleic acid and in one instance I obtained a froth and by reducing the agitation, the mineral sinks, and by again increasing the agitation the mineral will again float.

Q. 65. You mean all in the same mixture, by alternately agitating differently?

A. By alternate procedures, first obtaining a froth and then sinking the mineral and then obtaining the froth again, and I presume the operation could be continued alternately in the same manner for an indefinite length of time. However, I have not tried it more than several times each. The percentage of oil was upwards of one per cent—one per cent plus relatively to the ore. I think I used one and one half per cent of oleic acid relative to the ore used and the agitation was constant for from five to ten minutes for

3305 each procedure.

Q. 66. Now, as the representatives of the plaintiff are going to visit the Butte & Superior mill tomorrow I think it would be a good idea if you take this time now and make a little sketch, flow sheet, and explain it to them. There will be time enough to do that?

A. Yes, I will get my flow sheet here.

Q. 67. You can do it on the board if you wish to?

A. Well, I can do that although I have prepared, several days ago, a large flow sheet, and you can observe any points on it just as well as looking at a diagram upon the blackboard.

Q. 68. Have you sent for it?

A. Yes, it will be here in just a moment. This flow sheet represents the flow of the material and the machines used in the flotation plant at the Butte & Superior Mining Company. It shows a plan

view of the various machines that are used and there are eight in number, all identical, alike.

Q. 69. What does each one of these units show, the circle and a triangle at the end of it?

A. I may start in this way; this is one machine which we call a pyramid machine, which consists of seven cells. Each one of these agitating cells that I am pointing out here in the center has two spitzkastens, one on each side of it. There is a double row of spitzkastens and a single row of agitators to each primary machine. There are eight of these primary machines in the flotation plant that
3306 treat the same material. The material as it comes to the flotation plant and goes to this machine is practically all alike, and there is a distributor that divides it into eight equal portions. Here we have a cleaner and a recleaner machine which takes the product from the roughing machine and retreats the concentrate for the purpose of obtaining a purer grade. Now, I may follow this way, the flow of this in a general manner, and if there are any questions I can stop and answer them as I go along. For the purpose of illustrating and not to confuse with a great number of lines on each one of these pyramid machines, as they are all alike, I have selected one of them and on it I show the various products that are made and where they go.

Mr. Garrison: What number have you selected?

A. I have selected No. 7, and it shows by the red lines where the products go. That will not confuse the other machines, and the products from the other machines, joins along with No. 7 so we can consider the whole plant, when we speak of No. 7 pyramid. The original material coming to the flotation plant, which is the tailing from the concentrating or wet separation part of the mill is indicated by the words "slime and tube mill product." That material comes from the concentrating department and goes to two 36 inch elevators, No. 1 and 2, where it is elevated to a junction box indicated by numeral three. The junction box has an under-flow and an over-flow. The under-flow goes to an 8-way distributor from
3307 which it is distributed to these eight pyramid machines that I have just described. The over-flow goes to what we call the sludge tank, which is just an alleviating tank to take the variation in the feed that is discharged from the elevators. The underflow from the sludge tank flows to the elevator again and is a closed circuit so the sludge tank takes care of any excess of material that may come at any one given time. Now, before being distributed to the 8 pyramid machines, the feed is sampled by an automatic sampler, designated on this flow sheet by the numeral five. After being distributed we follow down to No. 7 primary, and if it was retreated in No. 8 it would be the same for each one of them. The material enters No. 1 cell. And as I said before each primary machine is a unit in itself and consists of seven cells. These seven cells are attached in series and the feed enters the first at this point, travels from the spitzkasten here into the next one and so forth down until it reaches No. 7 and through No. 7. That is the general flow of the material through the machine. Each one of the cells has two spitz-

kastens, one on either side of the agitating cells, where concentrates and middlings are taken off. The first three produce a rougher concentrate where—which is Nos. 1, 2 and 3. The next four, Nos. 4, 5, 6 and 7 produce a middling, which middling goes back again to these 36 inch elevators before mentioned and to the original feed, coming back again to the machine. The rougher concentrate that is made in cells Nos. 1, 2 and 3 go to a 16 inch elevator
3308 where it is elevated to a small alleviating tank, No. 19, which is only a feed tank supplying material to the five cleaners which are all in pairs—have been in pairs, but are now as one machine—and as we follow the rougher concentrate it enters at this point and travels through these five machines or five cells to be washed, the same making a cleaner concentrate and a cleaner tail. Now, that cleaner tailing is no more than a middling product, the same as the concentrate recovered on the last four cells of the rougher machines and it goes back again to be retreated together with the original feed that is coming at all times, and that is a continuous operation. Now, the cleaner concentrate that is made upon this cleaner unit is elevated again to this tank 20, and goes to the recleaner where a final concentrate is made. The recleaner tailing goes to the rougher concentrate elevator and the recleaner cells where it is in a closed circuit, it being a little higher grade than the cleaner tailing. Then the tailing resulting from the No. 7 cell of the rougher machine goes to air cells of the pneumatic type, there being 14 in number. However, I have not shown the 14 as I wished to reserve this space, but there are 14 of them—where a final tailing is made from these air cells which goes to the tailings pond and to waste. The concentrate or middling product which is produced by these air cells goes back again through the system as a middling and is retreated with the original ore that enters the machine or enters the plant from the concentrating department of the mill.

3309 Mr. Williams:

Q. 70. What is the arrangement of these air cells? Are they all in series?

A. They are all in parallel.

Q. 71. All in parallel?

A. Yes.

Q. 72. So that the tailings go through——

A. (Interrupting.) 14 of them.

Q. 73. 14 of them?

A. Yes, sir, in parallel.

Q. 74. One after the other?

A. Not if they are in parallel, no.

Q. 75. In parallel the tails would be divided into fourteen different lots, each going through one machine? Is that right?

A. Yes, sir.

Q. 76. That is what I supposed, but I wanted to make it clear?

A. Yes.

Q. 77. Where do you put your oil in? I suppose you use oil, a little?

A. Yes, I think we do, a little. We put the oil in before it comes to the elevator. We have put the oil in at the junction box and also the sludge tank. We are provided to put oil in at these places, but right now we are adding the oil to the feed as it comes to the flotation plant from the water concentrating department.

Mr. Garrison:

Q. 78. Can you indicate on there the place where you feed the oil?

A. (Witness indicates on drawing).

3310 Mr. Garrison:

Q. 79. How have you indicated it?

A. By putting a circle and "oil feed" on there.

Q. 80. Have you any copies of this drawing?

A. I haven't any copies of this particular drawing but I will endeavor to furnish copies for tomorrow, a number of them, so that your representatives will be as familiar as they would be if they had this one.

Whereupon an adjournment was taken until Monday, April 30th, 1917, 10:00 A. M.

10 o'clock a. m. April 30, 1917.

Mr. Garrison: If your honor please, two weeks ago yesterday we served upon defendants a notice to produce various papers, and in response thereto, after producing some papers, they stated that they would be unable to definitely respond to the balance of the notice until they had had further opportunity to make search, with which your honor concurred, very properly. It has now been two weeks that they have had this opportunity, and I desire to renew the call, particularly with respect to the vouchers, checks or other evidences of payment of moneys by the defendant corporation to James M. Hyde.

Mr. Kremer: If there is anything of the sort found we will produce it.

The Court: Are you able to answer now?

3311 Mr. Kremer: I can not answer now because I have not paid any particular attention to the inquiry, outside of my first inquiry. I will ascertain at the noon hour if they have found anything. If they have, they will be glad to produce it.

Mr. Garrison: The suggestion was that they had to communicate with New York, and they have had time to do that.

Mr. Kremer: If we have found anything we will produce it. I don't know whether they have got anything from New York or not. I have not inquired since the first day.

The Court: Are you ready to proceed this morning?

Mr. Kenyon: If your honor please, we noticed a motion in this case, for leave to file an amended and supplemental bill. I don't know whether there will be any objection to it.

Mr. Kremer: Yes. We desire to object to the filing of the proffered supplemental and amended bill for the reason that said supplemental bill is not a supplemental bill within the contemplation of law or the process of this court, in that it sets forth only the matters which were known to the complainant and plaintiff during practically the entire pendency of this suit. For the further reason that no proper or sufficient or any showing has been made which would justify the filing of the supplemental or amended bill. The paper proffered is accompanied by a notice that the complainant will, on April 30th, move the court for leave to file a so-called supplemental and amended bill of complaint, a copy of which is attached to
3312 the notice. There is no other showing made to the court. We object for the further reason that the so-called paper or document is conjunctive, in this, that it purports to be a supplemental, as well as an amended bill, and no showing is made to the court, by petition or otherwise, which would justify the filing of the bill as drafted. For the further reason that the bill, upon its face, discloses the fact that under the law governing the filing of supplemental pleadings, and particularly supplemental bills, and under the decisions of the courts regulating the filing of the same, this supplemental bill is improper for the reason that it sets forth only matters which were disclosed, by the very nature of the allegations, to have been known to the complainant at all times during the pendency of this suit, and the application for leave to file the supplemental bill is not timely and was not made until this case had proceeded a number of days, although at all times the complainants, according to their own allegations, were advised of the conditions therein contained. That is shown by their own allegations and the allegations in the prior pleadings in this case.

For the further reason that the attitude of the complainant in now applying to file this supplemental bill is not one of equity, in that they came into this court and proceeded to introduce their testimony and concluded their case, plaintiff holding itself out as the owner of this patent and entitled to proceed with this lawsuit, with a view to obtaining such benefits as it might obtain through the
3313 lawsuit, withholding from the defendant all of the information now contained in this supplemental bill, and no application was made or notice given to file a supplemental bill until after the defendant had placed upon the stand Mr. John Ballot, whose testimony disclosed that it was known to them at all times, the fact that this plaintiff was not the real party in the case.

We further object for the reason that in order to file a supplemental bill it must be apparent that the application is made timely and that the matters and things set forth in the supplemental bill are of such a character that they develop during the pendency of the suit and were acted upon with expedition and with diligence when they were disclosed. And it further appears that by the exercise of due and reasonable diligence facts, or alleged facts, set forth in the supplemental bill should have been presented to this court long before the time of their application.

We further object to the filing, if I might segregate it—I don't

know how I can when the paper is labeled one and the same thing. A conjunctive appellation of supplemental and amended bills—but referring to that portion of the bill that sets forth what is purported to be amendment to and in substitution of paragraph 8 of the bill of complaint, the defendant objects to the alleged amendment for the reason that it is not timely for the reason that all of the contentions therein contained were objected to by the defendant herein at the time of the attempted introduction of proof and a ruling was made that the complaint was broad enough to admit the character of testimony to which the objection was directed. That being
3314 so, it is not timely now to propose this amendment, and particularly is the amendment not to be allowed for the reason of the long delay and lack of diligence in filing the same, and for the further reason that the said amendment, under its very allegation, is not sufficient in law, and by reason of this fact it is apparent it should not be permitted to be filed in view of the fact that no showing accompanied it and it is contrary to the decisions of the Supreme Court of the United States involving a like matter of law.

We submit the motion. Has your honor looked—I don't know as it is just fair to submit it. I think I should advise the court.

The Court: I certainly should know what is brought into the case or attempted to be brought into the case by this new bill.

Mr. Kremer: If your honor please, by this supplemental bill, first, as I have stated in the objection, there has been no showing made to this court. My understanding of the practice is a showing must be made to the court for leave to file a supplemental bill; there must be something affirmative before the court, and there is nothing before the court, not a mere paper to which is attached a notice. I think upon that question of practice we all have an understanding of what is necessary. I don't know that all that is necessary is to present a paper. I think you must make a showing to the court, your reasons for desiring to file the supplemental bill. Now, I understand the further fact—I wish you gentlemen would correct me if I misstate this, because I am not quite as familiar as you are with it.

3315 Mr. Kenyon: We will be glad to do so.

Mr. Kremer: I think I can state it from the allegations. The supplemental bill alleges that the plaintiff, Minerals Separation Limited, entered into a contract or agreement of American rights, using the term broadly, of this patent on the 10th day of October, 1910, when there was granted to the Minerals Separation American Syndicate, Limited, the plaintiff herein, certain rights under said patent for a term of years. These rights were renewed by a written instrument from time to time up to 1916. Now, although it is shown to have been known that the Minerals Separation American Syndicate, had certain rights, they were not made parties plaintiff to this suit. We had no information, that is the defendant. And later it is alleged——

Mr. Kenyon: You want me to correct you if you have made a misstatement of the facts?

The Court: You better let them take that and they can present their side of the motion.

Mr. Kremer: All right, I would be very glad to have them state it.

The Court: You have completed your objection, Mr. Kremer?

Mr. Kremer: Yes, I have completed my objection.

The Court: Let them proceed with their motion.

Mr. Kenyon: The objects of the amended and supplemental bills are several. I will take them up in order. First, it is decreed the mandate of the Supreme Court in the Hyde case, the dis-
3316 claimer that followed in consequence and the final decree that was entered in the Hyde case. Attached to this supplemental bill of complaint is a full copy of the mandate, with its date; of the disclaimer with its date; and of this final decree with its date, these documents showing that these various things occurred and they are proper matters for supplemental bill, not under the ordinary and accepted practice, but under the very rules of this court itself, where in rule 24, under "Supplemental Proceedings" it is stated: "Upon application of either party the court or judge may, upon reasonable notice and such terms as are just, permit him to file and serve a supplemental proceeding, alleging material facts occurring after his former pleading." Under this branch of it, this branch of our supplemental bills comes in.

Another branch of the supplemental pleading is what our motion and bill substantially amounts to, a plea to intervene by Minerals Separation North American corporation, to acquire title on December 7th, 1916, such title as the Minerals Separation North American corporation, acquired on December 7th, 1916. This supplemental traces back to its origin along in 1913. Giving the original document of July—some day in July, 1913, when Minerals Separation, Limited, one of the plaintiffs and Minerals Separation American Syndicate, 1913, an intervening British corporation, together agreed, the one to sell and the other to purchase the beneficiary interest in the American patents, including the patent in suit, upon the happening of certain conditions and the making of certain payments. Our
3317 supplemental bill alleges that these conditions were finally perfected, and these payments were finally made in October, I believe it was, October 6th, 1916, at which time, last October, became invested in this intervening American Syndicate, the beneficial interest of these patents, legal title to which still remained in the Minerals Separation, Limited. And, as I say, on December 7th, this new corporation that now asks to be admitted as a party plaintiff, Minerals Separation North American Corporation, acquired the entire right, title and interest of this intervening American Syndicate of 1913 in this patent for whatever that 1913 Syndicate had, and in all causes of action that had accrued to this 1913 syndicate in the interval of its ownership. Therefore, this Minerals Separation North American Corporation, that now asks to be made a party plaintiff, while not the owner of the legal title to the patent, that remains in the Minerals Separation, Limited, at the present time, is the owner of the beneficial interest in that patent, and is therefore in equity properly, and rightfully to be included as a party plaintiff; and for

the purpose of the accounting that we anticipate, should be a necessary party plaintiff to the end that the defendant itself may be protected from any further litigation connected with the same acts of infringement of this patent. And that is the purpose of bringing in this new plaintiff at this time, in defence of the defendant, so that every possible interest that has any equitable right of any kind in the accounting shall be actual parties to the accounting and bound by it. On the face of the papers the proceedings occurred as of
3318 the date October 6th last and December 7th last. It hardly appears that any additional affidavit of diligence need be filed as to the delay in the interval because no possible harm can have been occasioned the defendant by that, and this bringing in of this corporation makes the pleading now accord with the facts that were brought out for the first time in the testimony of Mr. Ballot. These are facts occurring then since the bill was filed, having to do with an equitable interest that will be concerned in the accounting and is properly brought in this form of pleading.

As to the amendatory character of the bill, it consists of two measures; first, as to the Hyde and the relations of this defendant to the defense of the Hyde suit. We strike out by this amended bill our allegation in that regard in the original bill and substitute an amended allegation, stating the facts as we now understand them, making the pleadings agree with the proof, the proof that has been brought out here in the last few days, and which we could not in the nature of things, have known until we saw this correspondence and examined these witnesses. That part, therefore, of the amendment is merely to make the pleadings agree with the proof.

And, finally, there is only one branch left, and that is a residuary interest, a certain residuary equitable interest in a third and the original American Syndicate that is called "Minerals Separation American Syndicate, Limited," which is the British Corporation of 1910.

Counsel, in following back these complicated title papers
3319 connected with these three successive American corporations, one of 1910, a British corporation, one of 1913, a British corporation, and finally this last one of 1916, an American corporation, discovered just within a few days for the first time that there was this residuary equitable interest, left hanging in the air, as it were, and never assigned to anybody, an interest that accrued—a right of action that accrued to this 1910 American syndicate, by reason of infringements occurring between October 10th, 1910, and October 10th, 1913, because as the papers show that we attached to this document, on October 10th, 1910, that first of the three American corporations became an exclusive licensee under the patent in suit, and so remained until October 10th, 1913, when its license expired by limitation, and when all other rights and interests that were vested in it, were, by the British counsel who prepared these papers, transferred to other interests and reverted to Minerals Separation, Limited. But there was omitted from that document, as it chanced, such interest as had accrued to that first American syndicate of 1910 in the recoveries that might be made against infringers who infringed

during that period, that is, from October, 1910, to October 10th, 1917. That happens to leave a small part of the infringement that will have to be accounted for here, in case a final accounting is decreed, and while an exclusive licensee under the authorities can not maintain an infringement in his own name——

Mr. Sheridan: Oh, yes, he can.

Mr. Kenyon: It can properly be joined with the owner of
3320 the legal title in such an action for infringement. That is correct, isn't it?

Mr. Sheridan: Yes.

Mr. Kenyon: The question of the legal title and the question of exclusive license for the period mentioned, that old syndicate of 1910 may properly be joined as party plaintiff, and that syndicate, which otherwise is now defunct, but still legally in existence, asks to be permitted to intervene here as a party plaintiff, to the end that even that interest, whatever it may be, and remote though it be, may be represented in the accounting, so that the defendant may never at any time hereafter be called upon by that ancient corporation to respond in damages for that infringement. That covers the whole substance of our amendment and supplemental bill, and seems to properly amend and supplement the pleadings, so that all interests, equitable and otherwise, that might by any possibility be concerned in that accounting shall be before the court and bound by whatever that accounting results in once and for all. If counsel for the defendant are not inclined to accept our statement—the statement of counse' I mean—that this residuary interest of many years ago was unknown to exist by the British counsel and unknown to the parties themselves and only brought to light by our investigation here recently, we will present an affidavit to that effect, or testimony in court. Now, that, it seems to me, is the only possible point on which any affidavit as to diligence would be required.

Mr. Kremer: After hearing the statement of counsel I ask leave to supplement my objections by three additional objections.

3321 Defendant further objects for the reason that under the statement of counsel, an attempt is being made to split the causes of action; for the further reason that under the statement of counsel the pleadings should not be permitted to be filed because, assuming that an accounting should be ordered—only assuming this by way of argument—it would be improper to permit this pleading to be filed, because, this being the date of the application for filing the alleged supplemental bill, under the statutes of the United States it would be impossible or improper to permit anyone, either the plaintiff or any one of the proposed plaintiffs, in the supplemental bill, to ask for an accounting for a greater period than six years, as the statute of limitation prescribes a six years' period for an accounting, and the six years would run back from today.

For the further reason, that this being an action in injunction and accounting it is improper to permit any party to intervene who has nothing more than an action at law, if an action at all, and it is an attempt to permit a party to become a party plaintiff whose right

of action, if any, would be confined to an action at law, an action for damages. I am now referring particularly to the last corporation—I can't keep track of their names—I think it is the Minerals Separation North American Corporation.

Having added those objections I would like to reply briefly to counsel.

At the outset, if your honor please, it was stated that the paper submitted was offered for the purpose of pleading a disclaimer. Such a position can not be tenable upon the face of this record.
3322 There has been filed here a proper supplemental answer, setting forth the fact that the plaintiff in this case did not file a disclaimer. Under the rule it is unnecessary for them to reply thereto and that issue is before the court regardless of their proposed supplemental bill, the question of whether or not a disclaimer was filed. That matter is before the court under the rules of practice, and the issue is joined.

Now, insofar as the pleading of the mandate of the Supreme Court of the United States in the Hyde case is concerned, the final decision in the Hyde case is pleaded upon the face of the record heretofore existing, and it is unnecessary to plead the mandate of that court. It is not the mandate that gives the decision any force or effect, and there is no attempt in this case and has been no attempt to admit the face of the record in the Hyde case. The existence or possible existence of that mandate would not give force or effect to any action that the plaintiff could take under this supplemental bill that they could not have taken under the original complaint herein on file, and particularly under the supplemental answer filed by the defendant herein. Therefore I say that there is no reason for the statement to the effect that this bill is made necessary by reason of a necessity of pleading the disclaimer or the mandate. The matters are before the court by implication of law, and there is no reason for tendering the supplemental bill at this hour. That this is in fact a petition for intervention, I take it that it can not come before this court in the guise of a supplemental and amended bill
3323 of complaint. There is a vast distinction between a petition for intervention and a supplemental complaint or an amended bill. Why, I say a vast distinction—one is the antithesis of the other, in this, that the petition in intervention is addressed to this court by a stranger to the proceedings, who asks leave to come in and have his cause litigated in the cause between these other parties. The supplemental bill is a proceeding, which, under the discretion of the court in proper cases, might be filed for the purpose of permitting then existing litigants to set up in the record something that has transpired subsequent to the filing of the original pleadings and the joinder of the issue. An amended complaint is a pleading directive in the nature of a curative character, to a pleading already in existence; and if this is, in fact, as counsel now states, a petition in intervention, it can not be offered to this court for filing in this guise.

Now, as to these various corporations I think that I was stating the case quite correctly. Regardless of the recontation of these vari-

ous rights, of these corporations at various times, the fact remains that these matters must have been known—and I am not speaking of counsel, because I take the statement of counsel that they did not know—but it must have been known to the officers of these corporations who, as I understand it are extremely closely allied—I am not sufficiently familiar with the organizations to make the broad statement that they are the same—but these facts must have been known to the plaintiff, and there is no showing that they were not known to the plaintiff. It is not a question whether counsel
3324 knew; the client may have withheld information from counsel, with design—I am not saying that they did, if your honor please, but I am only illustrating that the knowledge of counsel is not necessary. The very paper that is here presented admits that these contracts were in existence.

Now, then, the equity of this situation,—What is it? Before proceeding with the amendment, I would like to digress here to discuss the matter of this so-called supplemental bill. What is the equity of the situation? Suppose, if your honor please, this case had gone on without our discovery of this condition—and I use the word discovery of this condition advisedly—without our discovery of this condition, and let us suppose that that condition does exist, that in this litigation this patent will be declared invalid. When that decree is entered, decreeing the invalidity of this patent, what would have been the position of this defendant? Would not the Minerals Separation North American Syndicate, or Minerals Separation North American corporation, or any one of the other shadows that have lurked in this darkness, protruded themselves into the light of day and say "No, you are not relieved, because I claim a right, and you must litigate this all over again." Now, that is the position. These facts were known to them. It is the clearest case of doing equity that I have ever known. They come into equity and ask equity, and at the same time they have withheld the real parties in interest in this litigation, and it was only when we, in opening our defense, called to the stand the president of one corporation and chairman of the board of the other, and brought
3325 into this record the fact that there was still another party in interest. Now, that is the reason. There is a strong reason in equity that these things should not be done, and we seriously oppose the filing of this so-called supplemental bill at this time.

I don't want to needlessly take up the time of the court; I think I have stated my position as clearly as I can, but now, directing my remarks to the amendment or the portion of the bill designated as an amendment to the original bill: In the original bill they complain in paragraph 8—In that paragraph everything is set up, if your honor please, that is set up in paragraph 8, except the recontation, or at least an attempted narration of the plaintiff's interpretation of certain evidence in this case, which they have made in this proposed amendment. In paragraph 8, I objected to the introduction of testimony under it, as your honor will remember, and argument was had, and my objection was overruled.

(Counsel read paragraph 8.)

In paragraph 8 in the amended bill, all that they have attempted to do, and I believe counsel will agree with me in this statement, is to give their interpretation of the evidence. They may not subscribe to my interpolation of the word "interpretation" either, but it is their view of the evidence that is attempted to be set forth in this so-called amended bill, and it is improper because it is a pleading of their interpretation of the evidence. There is no reason on earth why this amendment should be filed. The issue, I submit, is raised by their paragraph 8 in this case, because your honor has ruled that
3326 it is properly in this case. Now, that being the state of the record, it is a useless thing and an improper thing to permit an amendment which sets forth merely an interpretation by the plaintiff of the evidence in this case, and we believe that, if your honor will examine the two paragraphs, that you will conclude that it is nothing more than——

The Court: In spite of the ruling which was made, they may think it wise to throw out an anchor to windward. There may be an appellate court.

Mr. Kremer: There is no reason, and there is no rule of pleading to permit the introduction into a pleading of an interpretation of the evidence. If it does state a condition which will permit them to have redress if they have been aggrieved, that is sufficient in law. They have set forth here an interpretation of the evidence. Now, I desire, to add this, before concluding; that in addition, after they have set forth their interpretation of the evidence, they say that to that extent—that is to say, to the extent of the letters patent in suit, 835,120, may vary as to claims 1, 2, 3, 5, 6, 7 and 12 and I included by the acts and operations that are complained of, that this defendant is estopped. You see? Leaving out of the matter of their attempted plea or estoppel, claims 9, 10 and 11. I think I have correctly stated that.

Mr. Garrison: Those are the ones that are left out?

The Court: The new one excluded 9, 10 and 11.

Mr. Kremer: Yes, sir, the new one excludes 9, 10 and 11. I think I should state this to the court, because that is the legal
3327 effect of this amendment, aside from the fact that this interpretation of the evidence is here incorporated. I am not going to read it, but I have read the short paragraph which sets forth not what entitles them to redress but merely the so-called evidence or their interpretation of the evidence which they claim to have been introduced in this case. Now, I cannot see the necessity of such an amendment, if under the original pleading all of the claims are included; this would serve no good purpose by way of relinquishment, because the law would relinquish them, and we submit that this supplemental bill is an improper document to be filed at this time, and that it is improper to combine the various elements there which are sought to be combined in this pleading, and there is no sufficient showing that the bill should be filed.

Mr. Kenyon: May I state just a word on one or two of these points? On the second day of the trial we gave defendant's counsel informal notice that we would prepare a supplemental bill, and there

was some discussion connected with it, and this is the outgrowth of that.

Mr. Kremer: Mr. Kenyon, I very much dislike to interrupt counsel, but may I ask you the question to avoid the necessity of rising again? Wasn't that notice given after Mr. Ballot had testified?

Mr. Kenyon: I think it was.

Mr. Williams: Yes, a few minutes afterwards, and I think that we should also say that counsel considered the matter on the train coming out here, and decided to file a supplemental bill as soon as they could study the numerous documents and reach a conclusion
3328 as to what was necessary to give to the defendant that protection which would arise from including all the parties who had any action against the defendant.

Mr. Kenyon; And we had to telegraph to the east to get some of these documents. Now, counsel speaks of a six year limit under the law. That is true. An infringement that occurred prior to six years before the filing of the bill of complaint is barred by the statute of limitations. Therefore, as to this 1910 corporation, there is no doubt that it could not prosecute an infringement occurring six years prior to the time, whenever this supplemental bill is filed. But that is a question of the extent of the infringement, a question to be properly brought before the master, and not a question to be determinative of whether that party could sue or not within the six years. It so happens here that it already appears in evidence in this case that the defendant's operations did not begin until the first of July, 1911, so it is merely a moot question here.

Now, as to the question of these two new parties here splitting actions, and that an exclusive licensee has an action only at law. In the second proposition, counsel is correct. When it sues alone it can sue only at law for damages that have been done it, but nothing is commoner in the administration of patent law, and the books are full of illustrations of the proposition that an exclusive licensee, although alone he can sue only at law for damages, may be joined with the owner of the legal title in a suit in equity for that same infringement, and when so joined can participate in the prayer for injunction and in the accounting for the profits, as well as for damages.

3329 Therefore, this that we propose is not a splitting up of actions, but just the reverse, a consolidation of actions. It is a non-splitting of actions; It is a consolidation of all of them into one action whereby with one proceeding and one accounting every right and every obligation of these defendants, and of all these plaintiffs shall once for all be determined. Defendant's counsel illustrates: Suppose we had kept these equitable interests in the dark, and had proceeded in the name of the owner of the legal title only and had in the end invited the catastrophe of a decree declaring the patent invalid that then we might have brought suit in the name of one of these exclusive licensees and sued all over again. We are quite anxious to save him from that possible disaster. We are—we ask that the exclusive licensee be joined here so that it will be bound

by that decision and never again be able to raise its voice. That relieves him and protects him. This court, under its own rule 19, has the broadest discretion in the matter. "The court may at any time, in furtherance of justice, upon such terms as may be just, permit any document, proceeding, pleading or records to be amended or material supplemental matters to be set forth in an amended or supplemental proceeding. The court at any stage in the proceeding will disregard any error defect in the proceeding which does not affect the substantial rights of the parties." Now, our opponent says it is not necessary to plead the decree in the Hyde case.

Mr. Kremer: No, not the decree.

Mr. Kenyon: The disclaimer?

3330 Mr. Kremer: No, the mandate.

Mr. Kenyon: Then it will do no harm to plead the mandate. Pleading the decree explains the decree; pleading the disclaimer and the interval between the two explains at all times the disclaimer and the final decree; and that a disclaimer can probably be treated is also permissible and is often done. In Fellows v. Borden, 205 Fed. 901, the Circuit Court of Appeals, Second Circuit, allowed the plaintiff to ask the district court to file a supplemental bill after a disclaimer, in order to set up the disclaimer, and the District Court allowed it and it was filed and the case was reheard on the merits and went to the Circuit Court of Appeals on the merits of the treating so amended. And as to the Hyde amendment, some of the allegations of our bill were incorrect. We wish them amended in accordance with the evidence. In some respects they were incomplete and we wish that incompleteness supplemented in accordance with the evidence, and made complete and the residuary right of this old 1910 corporation extended not only to counsel but to the parties themselves. They were ignorant of it until within a few days when we discovered this matter in conning over these numerous documents that were admitted in evidence; then were ignorant that anything had been left, any property had been left in that 1910 corporation. The purpose had been to absolutely denude it of every possibility, of every right of every kind. But this right of action and any interest in a right of action against infringers had during this period apparently been a thing unknown to British counsel and had not been included in any of the general language.

3331 We will, if your honor please, file an affidavit that the parties themselves were ignorant until within the last week or so, of the fact that there was any right of any kind with reference to this infringement left in the old 1910 corporation, if your honor wishes such an affidavit on file.

Mr. Kremer: I don't think that that would excuse them at all. The fact that they did not know that which they should have known is not any excuse. It is purely a question of law and legal right and we can apply the basic maximum ignora legis nemine excusat. They cannot take advantage of a condition of that sort by saying that they did not know or they supposed the record had been left in that condition. They could have come in here and sued for it, and alleged recovery. I do not care to take up the time of the

court, but I merely want to reply to one thing. Insofar as the amendment is concerned the only excuse offered for this amendment is that they believe that the amendment sets forth more nearly the state of facts. That is not a sufficient excuse. As a matter of fact, neither the complaint nor the amended complaint states the facts or any portions of the facts as disclosed by this present record before the court. The unimpeached record before the court at this particular time, in this case, is that Mr. Hyde had sold his rights, and that the Butte & Superior had purchased them for an expenditure equal to the amount of the cost of the litigation. There was no evidence of the control of the litigation or anything of that sort. Now, we submit the matter.

The Court: Does this supplemental bill purport to take the place of the original bill or simply an addition to it?

3332 Mr. Kenyon: An addition to it only in respect to one paragraph, paragraph 8 does amend it.

The Court: Well, the main feature seems to bring in these parties who have a right to share in the fruits, if there are any, for the plaintiff. There is an old maxim that courts of equity delight to do complete justice and not by halves. I will take the two pleadings and look them over and dispose of them in the morning. You may proceed with the case.

BEN. H. DOSENBACH resumed the stand for further

Direct examination.

Q. 81. Mr. Dosenbach, have you ever investigated the possibility of concentrating by flotation and a froth with the same amount of oil that is recognized for this Cattermole process in which the mineral is sunk?

A. I have.

Q. 82. How have you proceeded with this investigation?

A. I have performed an experiment in what is called the cone Gabbett, using a proportion of oil to ore that is over one per cent and which is very close to the proportion recognized in the Cattermole patent, that being 4 to 6 per cent relative to the metalliferous mineral content. The amount of oil relative to ore that I propose to use and that I have used is one and one-half per cent, which reduced

3333 to proportions compared to the metalliferous mineral content is about seven per cent. In the experiment I performed I used oleic acid and Butte & Superior ore.

Q. 83. Suppose you just describe the procedure before you do it so that we will know what to look for?

A. In the experiment that I am about to perform in the cone Gabbett machine, using a proportion of oil that is over one per cent and also a proportion of oil recommended in the Cattermole patent, I will use 300 gms. of Butte & Superior ore containing about 14.8 per cent zinc. I will add to that 1,500 cc. of water at a temperature of 35° C. I will use also 1 cc. of sulphuric acid concentrated and 5 cc. of oleic acid, which is equal to 4.5 gms. or one and one-half per

cent relative to ore. The agitation will be continued for possibly six minutes, at a speed of 1,600 to 1,700 revolutions per minute.

Q. 84. And what will the result be of that first agitation?

A. The result will be a froth.

Q. 85. And then what do you propose to do after you have obtained that froth?

A. I will reduce the agitation and it will be noted that the mineral sinks. And, by again increasing the agitation it will be noted that there is a froth formed.

Q. 86. A second froth?

A. A second froth.

Q. 87. And who will—and how will you conclude the demonstration?

A. I will conclude the demonstration by reducing the agi-
3334 tation again, sinking the mineral and separating the mineral in an upcast, as is done and recommended in the Cattermole patent.

Q. 88. And all of these operations will be conducted in the very same mixture?

A. They will.

Q. 89. Now, as I remember the Cattermole patent refers to the quantity of mineral, the metalliferous content of the ore. That expression does not mean the mineral itself, zinc?

A. Refers the oil to the metalliferous mineral.

Q. 90. What is the metalliferous mineral in zinc ore?

A. The sulphide of the metal.

Q. 91. You gave its contents 14.8 zinc. Is that metallic zinc?

A. Metallic zinc.

Q. 92. And how much of a per cent of blend in which that zinc is contained that is taken into account, the weight of the sulphur contained with the zinc?

A. 21.75 per cent metalliferous mineral or zinc sulphide would be equivalent to 14.8 per cent zinc.

Q. 93. Now the oil is one and one-half per cent of the weight of the ore and the ore contains approximately one-fifth metalliferous mineral, that is a little over twenty per cent?

A. Yes.

Q. 94. So that you arrive at the relation of the oil to the metalliferous mineral by multiplying that one and one-half per cent by approximately five?

3335 A. Yes. In actual figures it is less than five so that the amount of oil relative to the metalliferous mineral present or the zinc sulphide amounts to 7.0—something which is just a little above seven per cent.

Q. 95. Now I think you may proceed with the experiment?

A. If a representative of the other side is here we will give them a sample of the oil we are going to use.

(Performing Test #33.)

I have now placed into the cone Gabbett machine 300 gms. Butte

& Superior ore. I will now add 1,500 cc. of water at a temperature of 35° C.

Mr. Williams: I would like to give notice to Mr. Scott of a request for a little specimen of each of these froths that is to be made. I think one-tenth of a gramme of each will be satisfactory to us if that will not interfere with the operation.

The Witness: It will be a pleasure to give it to you. After having added 1,500 cc. of water I will add 1 cc. of concentrated sulphuric acid and will also add 5 cc. of oleic acid and will start agitation.

Mr. Scott:

Q. 96. Now, Mr. Dosenbach, just state what the result of that experiment has been.

A. After stopping agitation, having agitated the mixture for a period of six minutes, a highly mineralized froth appears on the surface and the tailings are now settling and are very clear—appear to be very clean, and are comparatively light in color, settling very rapidly. The mineral froth that was formed is about one and one-eighth inches in thickness.

3336 Q. 97. Now, Mr. Dosenbach, you are next going to remove the baffles?

Mr. Scott: I would like to have your honor see the process that goes on when he removes the baffles.

Q. 98. Mr. Dosenbach, will it interfere with you at all if you would agitate it with the baffles in before you do it?

A. No.

Mr. Scott: He will give it the same agitation he did to make the froth, for a few seconds, and then he will change the agitation for the next step. That is the way he made the froth, with the small baffles in.

Q. 99. Now, go ahead with the next step so the court can see the difference in the way of agitating it.

A. It has a sort of a honey-comb structure on top, pitted.

Q. 100. What do these pits come from?

A. The release of certain air that allowed these pits to form.

Q. 101. What have you just done with the belts?

A. I have changed belts so as to get a lower speed. This rheostat and motor would not allow for a slow speed.

Q. 102. The speed before was about 1,700 revolutions per minute?

A. No, I took the speed to be 1,450 while it was operating.

Q. 103. Now it will be what?

A. About 300.

3337 Q. 104. You are going to leave the baffles in?

A. Yes, I am going to leave the baffles in.

Q. 105. How long are you going to agitate it this time?

A. It usually takes five to ten minutes to take the air out of there, out of the pulp.

Mr. Scott: Let the record show that the agitation was stopped in five minutes.

Q. 106. And then what happens, Mr. Dosenbach?

A. The mineral sank to the bottom; there was no semblance of a froth present on the surface.

Mr. Williams:

Q. 107. Just a few little particles here and there?

A. Just a few little particles here and there, possibly ten or twelve.

Mr. Scott:

Q. 108. Now, what do you propose to do next?

A. I will increase the agitation as agitated before and the result will be a froth or I hope it will be.

Q. 109. And after that you propose to form the granules again and separate them in the up-cast?

A. Separate them in the upcast. You can see that the mineral has sunk to the very bottom.

Q. 110. Just show the court the upcast before we go any further.

A. The upcast is a sort of a classifying arrangement whereby these heavy mineral particles that have now settled in the Gabbett——

Q. 111. Coming in here?

3338 A. They will be emptied into the classifier or upcast.

Q. 112. And what is this tube leading into the bottom?

A. That is water that is fed from the tank up above, which supplies a flow sufficient to cause the hydraulic action in the upcast.

Q. 113. The water will come up through the glass tube?

A. It will and carry with it the light gangue material you see now in the machine.

Q. 114. And what will become of the granules?

A. The granules will sink to the bottom and be caught in the bottom, which is this part of the upcast.

Q. 115. And these granules will be the same material out of which these froths have been formed?

A. Absolutely. I have again agitated the mixture for one minute at the same speed as before, being about 1,450 revolutions per minute.

Q. 116. When you say "as before" you mean as when you formed the froth before?

A. When I formed the froth before, at 1,500 revolutions per minute, and the result was a froth of the very same character as obtained before.

Q. 117. You might simply continue with the last step?

A. You notice along the side of the froth the clear portion on the particles of the froth which are evidently air bubbles, and it

3339 shows the clear portion where the froth sticks to the side of the glass.

Q. 118. What do you mean by the clear portion?

A. That is quite distinct, here is one and there is one.

Q. 119. You mean the black spots?

A. Yes, where there is no mineral present. Would you like a sample of that?

Mr. Williams: We might. We might get some information out of it. Let us have it.

Mr. Scott:

Q. 120. You ran this the same five minutes you did before?

A. No, it takes longer.

Q. 121. Why should it take longer?

A. It takes longer to form the granules than it does to form the froth because in working with a Cattermole machine, the cone Gabbett, it carries in quite an extensive amount of air through the cone and naturally during the process of agitation there will be a considerable amount of air taken in.

Q. 122. Referring to the fast agitation, or either of them?

A. Either one of them, for a short period. And it is in order to displace the air that is taken in after the first agitation that the slow rolling of the second period of agitation is necessary to be continued for a considerable length of time.

Q. 123. To get all the air out?

A. To get all the air out.

3340 Mr. Williams:

Q. 124. That is, that your present operation is one to get rid of the air?

A. Yes.

Q. 125. The machine introduces air at the same time?

A. Yes, it is very efficient for introducing air.

Mr. Scott:

Q. 126. How does the amount of air introduced when it is going slowly compare with the amount introduced when it is running rapidly, as you did when you were making the froth?

A. Very much less when it is slowly revolving as compared to when it is rapidly revolving and the froth is formed. I have agitated for a second period of five minutes and the result has been that there is no froth present. All the mineral has sunk to the bottom of the vessel. I will now proceed to separate the sunken mineral by the upcast classifier arrangement. The heavy particles are sinking and the gangue particles are going up. This (indicating) showing of the distinct mineral particles being heavier, and the slime gangue particles being the lighter here (indicating), are carried over by the up-current of water.

Q. 127. Have you got a stirrer so you can stir up those tailings so the court can see them?

A. I can catch some in my hand. I will allow them to settle a few minutes, and when the slimes have settled so there is an appreciable amount at the bottom, they can be noticed. There are a few

floating particles of mineral in the upper part of the upcast
3341 at the time that I am draining it. You can now see the mineral and granules that have been separated in the upcast; they all occupy the lower portion of the upcast, or the bottle.

Q. 128. Does that look like a clean separation?

A. Yes, a decidedly clean separation, especially so in the apparatus that I used, being a small apparatus.

Q. 129. Are you going to sample it?

A. Yes, I would be very glad to sample it and give the other side an equal portion of the sample. I will allow the tailings from the overflow of the upcast to settle, so you can notice its condition, being deprived of the mineral.

Q. 130. I don't think you described the other portion of the operation in the upcast. I think you had better give a description of that, of the upcast and the bottle and the launder and just how you operated.

A. The upcast consists of a vertical cylinder about two inches in diameter and about 30 inches high, to which at the lower end is attached a bottle, and through which hydraulic water is introduced, causing an up-current through the vertical cylinder.

Q. 131. That was clear water?

A. Clear water which acted as an upcast, so that when the total material from the Gabbett machine was introduced into the top of the cylinder or upcast, the uprising current of water carried the lighter portions of the mixture, which was the gangue material,
up to the topmost portion of the cylinder, where it overflowed
3342 into a receiver. The heavier portion, being the mineral, sunk in the presence of the uprising current of water, and was collected in the bottle at the lower end of the cylinder.

Q. 132. And in what condition was the mineral collected in the bottle at the lower end of the cylinder?

A. The mineral that was collected in the bottle at the lower end of the cylinder was in a decidedly pure state, containing very little gangue material, or insoluble.

Q. 133. On Saturday you performed an experiment with 25% of oil, petroleum distillate, relative to ore, which was Utah Copper retreatment classifier overflow. I won't ask you to perform another experiment of that kind, but have you done a similar demonstration with Butte and Superior ore?

A. I have conducted a similar demonstration using the Butte & Superior ore.

Q. 134. Can you give an approximate description of the details of that experiment?

A. In that experiment that I performed I used 300 grams of Butte & Superior ore, 1,500 cc. of water, at a temperature of about 30° Centigrade, one cc. of concentrated sulphuric acid, 75 grams of kerosene, which is the equivalent of 25% of oil relative to ore. This experiment was performed in the square glass jar machine, and the agitation was continued for approximately three minutes at a speed of about fourteen to sixteen hundred revolutions per minute. The

result of that experiment was a very copious froth containing
3343 the zinc sulphide mineral, and showed a very good degree of concentration.

Q. 135. Can you give descriptions of the demonstrations that will be illustrative of the present mill practice on the Butte & Superior ore; I don't think I will ask you to do them, but I would like you to give the details of the operations, one in using less than 1% of oil and another more than 1%.

A. I can. I have performed several experiments of that nature and I can repeat the same if so desired.

Mr. Williams: I think that if we are going to have any testimony as to experiments which illustrate the operation of the Butte & Superior—While I don't want to take up the time of the court unnecessarily—still, it does seem to me that we ought to have the experiment rather than the secondary evidence of the description by the witness.

Mr. Scott: Well, I will have Mr. Dosenbach perform the experiment if you wish. My idea was to have him give the laboratory proportions and procedure and leave it with you if you wanted to consume the time to see them.

Mr. Williams: All right, we may do it that way.

Mr. Scott: I might suggest at this time that we have thought it would be very informing if the court would visit the Butte & Superior mill simply for an ocular impression of the process on a large scale.

If the court is willing we would be very glad to arrange for
3344 that. I am not informed as to whether the court has actually seen the flotation operations on a large scale or not.

The Court: No, I haven't. Well, I don't know—of course I am hopeful that I will be sufficiently educated for a metallurgist before I get through; but whether I am yet ripe enough to judge by looking at the process I am not sure. Do you think it will assist me?

Mr. Scott: It always gives me more of a grasp of things of this kind if I can see them in actual operation. There are many things that we have to explain that will be more clear by seeing it. Of course in the mill these froths do not accumulate in these masses that we see here, and then have to be taken off all at once, but there is a constant movement through the cells, and the froth is constantly overflowing a lip as it is being formed.

Mr. Garrison: I would like to suggest to your honor, that if you do think well of inspecting of the procedure at the Butte & Superior, that you, at the same time inspect the proceedings at the Timber Butte mill, which is using ore from the same vein, and is avowedly using our process, being a licensee of ours, and where the amount of oil is from one-half to three-quarters of a pound to the ton of ore.

The Court: Well, some time during the progress of the hearing we will try and do that.

Q. 136. Now, could you give a description of what you
3345 think is the best illustration of the procedure at the mill?

A. A description of the process that would be applied in a small apparatus as being descriptive of the operations at the Butte

& Superior plant would be an experiment carried out in the Janney machine, which is this machine that I refer to, the Janney Flotation Machine. This is the machine that is now being used at the Butte & Superior flotation plant, and in carrying out the experiment I would use about 30 pounds of oil to the ton, or 1½% of oil mixture.

Q. 137. What are the ingredients of the mixture. I take it it is the same mixture used at the Butte & Superior?

A. Substantially so, yes. 70% of fuel oil, 18% of pine oil and 12% kerosene. The proportion of ore to oil that I would use would be 400 grams of ore and about 2,000 cc. of water. I would use sulphuric acid and copper sulphate, as both are being used, and the exact proportion of sulphuric acid to 400 grams of ore would be .9 of a cubic centimeter. I would also use 1 cc. of copper sulphate solution.

Q. 138. What does the copper sulphate do?

A. The copper sulphate assists materially in the recovery and grade of the concentrate produced. It assists the acid in its action.

Q. 139. Is the use of copper sulphate to your knowledge recommended by any of the literature of the art?

A. Yes, I have found in the Everson patent the use of copper sulphate is recommended as being one of the salts that can
3346 be used in place of the sulphuric acid or together with the sulphuric acid. It is very distinctly brought out, the use of the various salts in the Everson patent. With 400 grams of ore I will use 6 grams of oil mixture, which is equal to 1½% relative to the ore, or 30 pounds per ton of ore. This operation carried out in the Janney machine will show to a great extent, and as near as possible the laboratory method setting forth the actual practice.

Q. 140. This Janney machine comes nearer illustrating the mill operations than the jar, doesn't it?

A. Decidedly so, yes, because during the operation of the Janney machine the froth may be taken out as it is being agitated and brought up to the surface; consequently it is not necessary to stop agitation and let the froth rise to the surface and then be skimmed off; but it can be done as it is being agitated and flowing into the spitzkasten—the froth can be taken off. Now, it might be well to show a comparison of the two experiments, using the same proportions of oil to ore and reagents in the square glass jar, as against the Janney machine.

Q. 141. Have you the motors so that you can do both at once?

A. Yes, I think I can do both at once.

Whereupon further — was adjourned until 2 p. m.

3347 2 p. m. April 30, 1917.

Mr. Garrison: With the permission of the court, may I ask for the response of Mr. Kremer as to the result of his search?

Mr. Kremer: I beg your pardon, Mr. Garrison, I entirely forgot to inquire. I will go and inquire immediately.

Mr. Scott: Mr. Dosenbach was about to perform two experiments, if your honor please, representative of the oil mixture in the quan-

tities used in the Butte & Superior plant, and he has arranged to do both of these experiments at once to save time that would be consumed by doing one after the other. He will do one of the experiments in the Janney machine, and in doing it he will try to take off part of the concentrate first, representing what is taken off in the real machine first, and then in a separate basin will take off the rest, which will represent the middling, or the material which is returned. In this glass jar machine he will use the same mixture and the same ore, to illustrate the difference between those two ways of doing it.

(Test in Janney machine, test No. 34. Test in glass jar machine, test No. 35.)

The Witness: I think I have stated what I will use; the percentage of the oil mixture in each instance will be 1½% relative to the ore. I will start the square jar machine and let it continue while carrying on the operation in the Janney machine, and by the time the latter is finished the other will be finished.

3348 (Both machines running.)

The Witness: What I am doing now, scraping off the froth from the Janney machine, represents what the scrapers do. In the actual plant there are scrapers which carry off a little of the froth every time it comes around; otherwise it would pile up and come over the sides. I will stop it now and take this first concentrate, if anybody wishes to see it.

This second basin, its contents represent the middling, or approximately so; although, in the lower stages of the actual machine we take the middling product after taking off the richer product that comes off first. This of course is a very much lower grade froth than is the actual case in the machine. In the mill the lower machines take off the middling, there being less mineral in the ore at that time. As a matter of fact in an operating plant we have the water level raised much higher than this; in the latter part of the machines it is higher than in the first part of the machines, which I show now. (Adding water.) Now, this is the water level about up to this point, and in the last cells the water level is much higher. This shows a froth coming off now in which there is very little mineral, which can be seen by the clear bubbles. There being very little mineral present, there will not be much mineral in the froth.

3349 (Going to the glass jar machine.)

Here is the froth that was made in the glass jar machine with the same percentage of oil. The only thing that we had reference to in this experiment was to show—was that there might be criticism about some of the oil going off during the first operation in the Janney machine, and this experiment is to show the similarity between the froths.

Mr. Scott:

Q. 142. What causes the bubbles to break down in the Janney machine so quickly?

A. There is no more agitation.

Q. 143. And what is left there?

A. There is very little mineral left; most of the mineral has been taken off, consequently this is a very good tailing, which I should be glad to have analyzed. The bubbles and possibly the froth before the machine was stopped showed that they were clear, and that very little mineral was contained in them; consequently when the agitation was stopped, the bubbles broke down.

That will complete the experiment, with the exception that I would like to take off the tailings at this point. We will number this station No. 1, the concentrate, and this will be the middling, No. 2, and I will also give one-half of these products to the plaintiff. Now, we will take out the tailing from the Janney machine and see what it looks like. (Taking out material from Janney machine.)

Now, I will put some of this fine slime into this other pan, since one pan will not hold it all, and later we will combine the two
3350 of them and half will be given to the other side. Now, what is in this pan shows very distinctly the poorness of the tailings. It is very light in color, and we will assay that and see just what it contains. It shows that the tailings are comparatively free from mineral. If it contains very much mineral after this action, the mineral would be noticed very distinctly and it can be seen that it has the same consistency throughout and is very light in color, showing that the mineral is gone.

Q. 144. Mr. Dosenbach, you better briefly describe the complete operation performed. I am afraid it is a little fragmentary the way it is in the record now.

A. The two operations that I have just completed are as follows: The one operation was carried out in the Janney machine and purports to set forth the operation as conducted at the Butte & Superior plant inasmuch as laboratory apparatus is concerned. The proportions of material used in the Janney machine experiment was 400 gms. of Butte & Superior ore containing approximately 15.9 per cent zinc; 1900 cc. of water was used at a temperature of 30° C., 0.9 cc. of concentrated sulphuric acid was used, which is equivalent to about 8 lbs. of sulphuric acid per ton of ore. 1.0 cc. of copper sulphate solution was used which is equivalent to about 0.1 pounds of copper per ton of ore, metallic copper. 6 gms. of oil mixture was used. This oil mixture consists of 70% fuel oil, 18% pine oil and 12% kerosene. The agitation consisted of approximately thirty
3351 seconds of mixing the oil with the ore and other reagents, and one minute and a half approximately for the period during which the concentrate was taken off and two minutes and a half constitutes the period during which the middling was taken off.

Mr. Williams: Will you describe what you did in that period of the operation where you said there were 30 seconds of mixing.

A. During the period of thirty seconds of mixing the ore, oil, acid

and sulphate were mixed by the agitation of the impeller blades in the machine for a period of thirty seconds.

Q. 145. And you confined these materials to the agitating chamber, did you not, during that particular operation?

A. I did, yes, the same as I would put them in the agitating mixer and add additional water later to fill up the spitzkasten. After discontinuing agitating the mixture and the middlings having been removed, I removed the tailings and all products will be assayed to determine their value. In the square glass jar machine at the same time that I performed the experiment in the Janney machine I performed an experiment wherein I used 300 gms. of Butte & Superior ore containing approximately 15.9 per cent zinc; 1500 cc. of water at a temperature of 30° C.; 4.5 gms. of oil mixture consisting of 70% fuel oil, 18% pine oil and 12% kerosene, this oil mixture being the same as I used in the Janney machine during the experiment that I performed in it. I also used 0.81 cc. of copper
3352 sulphate solution which is approximately 0.1 pounds metallic copper per ton. I used .67 cc. of concentrated sulphuric acid, which is equivalent to approximately 8 lbs. or 8.25 pounds of sulphuric acid per ton of ore. The agitation was continued for the same length of time as the total agitation in the Janney machine experiment. After discontinuing agitation in the square glass jar machine a highly mineralized froth formed on the surface, being composed of zinc sulphide and innumerable air bubbles. It shows a very good froth and the tailings as they have settled now are comparatively clean but the structure of the froth itself on the surface shows very distinctly the number of air bubbles that are present (exhibits sample to the court).

Mr. Williams:

Q. 146. I have no note of the temperature that you used in the Janney machine experiment?

A. 30° C.; 30° in both experiments.

Mr. Scott:

Q. 147. What would happen if you were to make a froth with say .2 per cent pine oil and then were to add enough to bring it up to one and one-half per cent and agitate again?

A. Well, I haven't done any experiment like that myself, I couldn't say—using pine oil?

Q. 148. Pine tar oil?

A. I have with pine tar oil, yes, sir.

Q. 149. Now, what would happen with pine tar oil?

3353 A. I have made an experiment like that and was curious to find out just what the condition—just what the addition of more pine tar oil would do after obtaining a result with a small quantity, to see whether there was any great difference between the froth that was obtained with a small quantity, whether a froth would be obtained with a large quantity, over one per cent, and to note whether there was any difference between the two, and I made a very

interesting experiment just that way in the cone Gabbett machine, the machine that I used this morning in court to demonstrate the Cattermole process.

Q. 150. Then I think I will ask you to do that one more experiment, and then we will be through, showing the formation of this froth with .2 per cent of pine tar oil and after getting that froth simply pour in enough more to bring it up to one and one-half per cent and aerate and agitate it again?

A. I can perform that experiment very shortly. (Performing test No. 36.)

Mr. Kremer: Mr. Garrison, while the experiment is being performed we can perhaps save some time. I have all of the vouchers here that we have in our possession—that is that we have been able to locate—I assume that they are all here because they cover a considerable period of time. Now, which of them do you desire to use.

Mr. Garrison: May I see them.

Mr. Kremer: I will give them all to you and just put them in order and let me know.

3354 Mr. Garrison: I may put these in at some future time.

Mr. Kremer: I can't urge you as to when you will put them in, but I wish you would look them over and use what you want to and return what you don't want.

Mr. Garrison: I will return them personally.

Mr. Kremer: Those that you don't offer we will.

Mr. Garrison: I intend to offer all of them.

Mr. Scott:

Q. 151. Now, add enough to bring it up to one and one-half per cent, that would be thirty pounds per ton?

A. Yes.

Mr. Scott: Your honor will notice on top of this froth, the appearance of it, that is with the small quantity of oil.

Mr. Scott:

Q. 152. Now, suppose you go right ahead on that if it has stood long enough.

—. ——.

Q. 153. What difference do you notice between the froth of that with the 1½% approximately, and the one with 0.2 of one per cent?

A. The froth with 1½% approximately is of twice the volume that it was with the 0.2 of 1%. The agitation is about the same, and it shows plainly that there has been more mineral recovered by the addition of the extra amount of pine tar oil over and above what was in it at first, the 0.2 of 1%.

Q. 154. What do you say in regard to the production of

3355 froth with the added amount of oil as compared with the first case?

A. It is very similar; in fact the air bubbles on the side can be

noticed, and the structure of the froth. There are a number of instances and places where the air bubbles are resting against the glass and are free from mineral, having discharged themselves by contact with the glass; that is noticeable all around. The froth with 0.2 of 1% was I inch in thickness, whereas this froth is about an inch and a half. These bubbles can be seen, and also the structure of the froth with this magnifying glass.

Q. 155. State what machine this was in, for the record.

A. I have stated that this machine that I performed the experiment in is a cone Gabbett, the same one that I performed the experiment in this morning of the froth and the granules separately. I wish to state that my intention was to increase the oil from two-tenths to one and a half, but in weighing it out I used more than the amount necessary to make one and a half, consequently the total amount of oil used in this experiment was 1.62%. I originally used 0.615 grams of pine tar oil in the first part of my experiment, and produced a froth of from three-quarters to one inch in thickness upon agitation. This froth was highly mineralized, containing zinc sulphide. I then added, after three minutes' agitation, which was the total length of time of agitation for the first part of the experi-
3356 ment, 4.25 grams of the same oil, and continued agitation for three minutes. The total amount of oil was 4.865 grams, or 1.62% relative to the ore content.

By Mr. Williams:

Q. 156. Have you given all the particulars of temperature and speed of agitation?

A. I will do so. It might be advisable to take off enough of the concentrate froth so as to give both parties an opportunity for analyzing the same so as to determine as to the purity and the grade.

Mr. Scott: Let the record show that some of the froth was taken off and offered to plaintiff's counsel.

Mr. Scott:

Q. 157. Have you finished?

A. I think so, but I don't know whether I stated exactly what was used in regard to ore. I used 300 grams of Butte & Superior ore, containing about 14.8% zinc. I used 1250 cc. of water at a temperature of 35° C. The amount of sulphuric acid used was 0.5 cc. The agitation in each instance was carried on for three minutes at about 1750 revolutions per minute.

Q. 158. I believe you have prepared some statements of the operations of the Butte & Superior Company with larger and smaller amounts of oil. Can you produce such a statement for the period from 1913 to date?

A. I have a statement showing the results.

Q. 159. Can you supplement this statement by information
3357 regarding individual days' operations if called upon to do so?

A. I can.

Q. 160. Were the operations during this period under your supervision—or part of this period?

A. From May, 1913, up to the present time, they were.

Q. 161. From May, 1913; that omits the first quarter?

A. That omits the first quarter of 1913, which is included in this record.

Q. 162. You have the record for that first quarter that you can refer to if counsel should want some information about the first quarter of 1913?

A. Yes, we have the records the same as we have for the succeeding period.

Mr. Scott: I offer in evidence the table entitled "Butte & Superior Mining Company, Flotation Operations."

Table admitted without objection, marked Defendant's Exhibit No. 158.

Q. 163. The first column entitled "float. plant feed, ore to float. plant" just explain what these headings mean, will you, Mr. Dosenbach?

A. The first column, "Float. plant feed" under which is added "float. plant. Dry tons and per cent zinc."

Q. 164. What is the difference between these two expres-
3358 sions "Float. plant feed" and under it "ore float plant"?

A. "Float. plant feed" means flotation plant feed; which also means ore to the flotation plant.

Q. 165. Mean the same thing?

A. They are synonymous, only it is to make less confusion. That is the actual ore that goes to the flotation plant.

Q. 166. That is the original material that goes to it?

A. The original material.

Q. 167. Now, the next is "flotation machine feed" and under it "ore to flotation plant plus circulating middling treated in flotation"?

A. That is the original material plus the circulating middlings which is present in the flotation plant itself.

Q. 168. Now, in that column which is entitled "Percentage zinc" under the—there seems to be no entries until the fourth line from the bottom. I presume that material was not assayed for zinc during that period?

A. Yes. For most of the time, and I can supply that for every day that we have it for, and for this period. But I haven't had time to make it up for these periods. It was left out by mistake.

Q. 169. But you can get it?

A. I can get it because we have daily assays on each day and I will supply it to fill out this sheet.

Q. 170. Now the next column "flotation concentrate, ton-
3359 nage and per cent zinc" seem to need no explanation. That is simply what is indicated there?

A. Yes.

Q. 171. As well as "per cent zinc" the same. You might explain again the difference between this apparent and estimated recovery.

A. The apparent recovery and the estimated recovery are both given in these tables. The apparent recovery is the recovery that is secured from the assays of the head, tailings and concentrate by the formula which takes into consideration the assay of each one of the products. That formula is the concentrate assay times the head minus the tailing assay divided by the head assays time the concentrate minus tailings assay. The estimated recovery as given in the sheet is the amount of metal recovered in the concentrate divided by the amount of metal in the heading. That takes into consideration the pounds of zinc in the concentrate as compared to the pounds of zinc in the heading.

Q. 172 The acid column is sulphuric acid of course?

A. I think they need no explanation. It is merely the pounds of acid per ton and the pounds of oil per ton. That is the amount of oil added to the original ore.

Q. 173. "Per cent oil in ore and circulating middlings treated in flotation" that is an assay figure, I take it?

A. Per cent oil in ore and circulating middling treated in flotation is determined by oil assays.

3360 Q. 174. By direct assay of the oil content?

A. Yes.

Q. 175. And that appears to be the same in the last four lines as well?

A. Next column "Pounds oil per ton contained in ore and circulation middlings treated in flotation" is merely the calculation from the analysis which is given in the column preceding. The per cent oil in concentrate, the next column following is by oil analysis of the concentrate, the per cent of oil in the tailings by oil analysis.

Q. 176. Can you just, for illustration, give us an example of how that figure "pounds per ton contained in ore and circulating middlings" how that is figured from the data in the preceding columns? For instance, take the entry February 4th to 28th, we have 25.4 entered under the heading I just read "pounds of oil per ton contained in ore and circulating middlings." Can you tell us jnst how that is derived from the preceding figures there?

A. That is derived from the preceding figures by multiplying the preceding figure by twenty, there being twenty pounds of oil, equal to one per cent, in a ton. Consequently if the per cent oil in ore and circulating middlings treated in flotation is equal to 1.27 per cent, then it is merely a matter of calculation to determine how many pounds 1.27 is equal to.

Q. 177. The only difference between these columns is one per cent and the other is pounds per ton?

3361 A. Yes.

Q. 178. Well, have you any figures in this table—well now, take these two columns, one is percentage and the other one is pounds per ton. Where is the sample taken for assay which gives the oil here, 1.27 per cent for instance?

A. The sample is taken of the feed before it enters the machine.

Q. 179. That is after the middlings and initial feed have come together?

A. Yes, exactly so.

Q. 180. There is no calculation then about determining the total amount of oil per ton of total solids? It is simply a direct assay?

A. That is all; there is no calculated amount.

Q. 181. The calculation you refer to is merely multiplying the per cent by twenty to get the pounds per ton?

A. That is all.

Q. 182. Have you ever checked up the amount of oil which was supplied to the feed with the amount discharged in concentrate and in the tailings?

A. During the course of our operations at the plant I have frequently checked up those figures.

Q. 183. And how closely do they come, approximately?

A. Well, I have found that they would come very close to the amount of oil actually added and equal very closely, the amount of oil contained in the concentrate plus the tailing.

3362 Q. 184. Can you give us an example of a calculation of that kind?

A. Yes, I have made a calculation in the period from February 4th to 28th, which is the first period that contains the oil analysis on the concentrate and tailing. As will be seen by the report, there was during that period from February 4th to 28th inclusive, 20.07 pounds of oil actually added to the ore as it came to the flotation plant. That is equal in round numbers to one per cent, the amount of oil actually added then for this period based upon the tonnage of 36,262 dry tons, was 725,240 pounds of oil used during that period.

Q. 185. The tonnage was 36,262?

A. 36,262 dry tons.

Q. 186. Multiply that by your 20.07?

A. Yes. The amount of oil contained in the concentrate plus the tailings was equal to 722,760 pounds.

Q. 187. Have you figured that percentage of error by deducting one from the other?

A. That is very easily done. That error is approximately three-tenths of one per cent.

Q. 188. Have you figured other periods to see if they come within the same order of accuracy?

A. Well, I figured the next period also.

Q. 189. And how close did that one come?

A. That came within practically one per cent.

Q. 190. And how close did they come?

A. They came within practically one per cent.

3363 Q. 191. That is the period from March 1st to 20th?

A. March 1 to 20, correct. I figured the next period and that came within approximately ten per cent, showing a variation. And the next period.

Q. 192. That is April 1 to 15, the next one?

A. Yes. The next period showed about fourteen per cent ap-

proximately. If you wish, I can figure out the exact amount, but that is approximately given from the figures. And, for instance, I have the last period April 1 to 15, that being 578,290 pounds or as against 502,850 pounds contained in the tailings plus the concentrate.

Q. 193. Was there any reason for that increase of error in these last two periods?

A. There was no reason that I know of, no.

Q. 194. I do not see the year 1917 on this left hand column here under the head "period." We have 1916, three quarters, that year, and then December 22nd to January 7th. I suppose that is where 1917 begins, that period extends over from 1916 over into 1917?

A. Yes, sir.

Q. 195. The years are not separated then, are they?

A. No, the third quarter of 1916 is on there separate from the year 1916 on account of having started a portion of the flotation plant during the month of December, 1916.

Mr. Williams: Mr. Scott, I suggest that on the exhibit in
3364 evidence you add dash and sixteen after December 22nd, and a dash or inclined line and 17 after January 7th. I have made that change.

Mr. Scott: That will read then December 22nd, 1916 to January 7th, 1917. Will you consent? I will simply change it.

Mr. Williams: I have changed it. I have the exhibit.

Mr. Scott:

Q. 196. Taking the three entries beginning with the one for the year, 1913, that is the first horizontal line, up to the years 1914 and 1915, that is the entries for these three years, I find that the gain of the concentrate improves somewhat, 47.8 for 1913, 53.03 for 1914 and 54.82 for 1915. Can you state the causes that led to this improvement?

A. Well, the chief causes were the improvements in the plant and the operation and the mechanical changes that were made, changes in the flow sheet and also the change in mechanical conditions whereby our operating conditions were made better.

Q. 197. I don't suppose you remember in detail all of these changes? Do you remember any of them?

A. Well, in May, 1913, as I think I stated before the plant was down for a period of six days during which time a complete remodeling of the flotation machines occurred. Then during the third quarter of 1913 more changes were made, and also in the fourth quarter of 1913 more changes were made, and during the year 1914 at various intervals changes were made in the flotation plant
3365 that entirely improved results—for instance, in 1913, speaking of the second quarter, we had four spitzkastens. Later on another spitzkasten on each rougher was added and continued that way until we had ten spitzkastens for each rougher. Then an additional cleaner was added—I may have a record of that right here, of the exact date. It was started rather late in 1913, a new

cleaner was started in November, which provides for two cleanings instead of one previous to that time. Then in 1914 general mechanical changes throughout the flotation plant and the disposition of the feed and so forth between one cell and another was instituted and five additional spitzkastens on each one of the roughers and later on the change from five passes to seven passes, which means that the feed has seven different agitations throughout its course through the machine. Then in 1914, the latter part of 1914 we started installing again another type of machine which was the Janney machine, and started the first unit in 1915, during the month of January, and the whole plant was in operation by May 1st, 1915. So that accounts particularly for the improved results in the grade of concentrate as well as the recovery for the period from January, 1913, through and including December, 1915.

Q. 198. I notice in the period March 1st to 20th, 1917, the third line from the bottom, that the tailings ran 1.54 zinc, and the apparent recovery was 90.84, concentrates, 47.50. Will you point out on this table the earliest date when a result equal to that was
3366 obtained—equal in efficiency, taking into account the grade of the concentrates and the recovery.

A. Well, the period that I should say nearly approximates it is the year 1915, when the recovery was 90.18%.

Q. 199. That was substantially the same order of recovery?

A. Also the grade of concentrate was higher during the period of 1915 than during the period of March 1st to 20th, 1917.

Q. 200. How about the loss in the tailings?

A. The loss in the tailings was of the same character during the period of 1915 as compared with the period of March 1st to 20th, 1917; I think that is the period which more closely corresponds.

Q. 201. Now we have here recorded 1913, 1914 and 1915. So that would be the third year of operations recorded on this sheet?

A. Yes, sir.

Q. 202. When the results you say were comparable with those obtained from March 1st to 20th. Now, from March 1st to 20th you were using how much oil?

A. The actual oil added to the ore going through the flotation plant was 21.3 pounds per ton.

Q. 203. During the year 1915 it was 1.49, was it not?

A. 1.49 per ton.

Q. 204. Now I see on this sheet it is recorded the amount of oil added per ton of ore. Do those figures represent the total amount of oil present?

3367 A. No, the total amount of oil present is much larger than that designated under the column "Per ton Ore to Flotation, Pounds." As shown by the figures in the column preceding it, "Pounds Oil Per Ton Contained in Ore and Circulating Middlings treated in flotation."

Q. 205. As I understand what you have stated, under the heading "Oil Pounds," those figures are the actual weight of oil added?

A. Absolutely.

Q. 206. Determined by actually weighing and by actually sampling and estimating the tonnage of ore going through the plant?

A. Yes.

Q. 207. And that figure giving the percentage of oil in the ore in the circulating middlings is the result of an assay of the amount of oil in the material going through these flotation machines?

A. Exactly so.

Q. 208. So there is no calculation about any of these figures; they are all determined by weight and measure?

A. Yes.

Q. 209. And then, according to these figures, will you just make a comparison between the amount of oil added for each of these periods and the amount found to be present by assay, using the figures per ton as they seem to compare?

A. During the period from February 4th to 28th inclusive,
3368 there was 20.07 pounds of oil added to the feed to the flotation plant, and 25.4 lbs. of oil present in the feed to the flotation machine.

Q. 210. And it was during that period that you just said the figures checked up within about 1%?

A. They checked up less than 1%. In the next period, from March 1st to 20th inclusive, there was added to the ore going to the flotation plant 21.3 lbs. of oil per ton, while there was in the flotation feed——

Q. 211. Including the middlings?

A. —to the machines, which includes the middlings, 30 lbs. of oil per ton.

Q. 212. During that period how close did you say the assays checked with the oil added?

A. About 1%.

Q. 213. Have you any explanation of the fact that during that first period, February 4th to 28th, the oil added was 20.07 lbs., and the oil present by assay 25.4, showing an increase of about 5 lbs. of oil, or a little over, while during this next period, March 1st to 20th, the difference between the oil added and the oil present as assayed is the difference between 21.3 and 30, or about 8.7 lbs.?

A. Well, my opinion now would be that it was due entirely to the operations. There was possibly more oil contained in the feed at different times that was sent back for circulation, and the mechanical conditions that existed, as I remember it, during that time,
were somewhat erratic, and we were remodeling the plant
3369 also at that time, and there was not a great length of time wherein the actual operating conditions were the best, and where the feed that was returned, or the middling that was returned was always uniform, but it averaged up pretty well. Some days we would make it higher than others. That may account for it.

Q. 214. Do you vary the number of cells in a series that return the concentrate as middlings, or do you run pretty steadily?

A. At times we vary that, depending on the material we are treating, and in order to relieve our elevators, should anything go wrong with them.

Q. 215. The machines are fixed so you can switch them from middlings to rougher concentrates?

A. Yes, they are.

Q. 216. What is your information as to the relation of tonnage returned as middlings and tonnage originally sent to the flotation machine; is as much material returned as middlings in circulation as is fed to the machine? That could hardly be, could it?

A. Yes; and at times there is more middlings than there is actually fed to the flotation plant.

Q. 217. More circulating load than the original supply?

A. Yes, but in circulating the middlings in our plant it joins the original feed and is elevated by a 36 inch elevator, and then distributed to the machines, consequently we have no distinct circuit of middlings and original ore remaining.

3370 Q. 218. I think there you have daily records arranged by months for several months. The January record begins on the 9th; how is it that it does not begin on the first?

A. The reason for that is that on that day we commenced operations using more than 1%, or 20 lbs. of oil per ton of material.

Q. 219. And you began your daily compilation from the time the large amount of oil was used in the whole plant?

A. Yes, sir.

Mr. Scott: I offer in evidence tabulation of daily results for the month of January, 1917.

Admitted in evidence without objection, marked Defendant's Exhibit No. 159.

Q. 220. Now, in this tabulation I find the heading "Flotation Machine to Date; Ore Flotation Plant Plus Circulating Middlings Treated in Flotation." The samples for those assays I suppose is taken between the sludge tank and the head of the machine, is it?

A. That sample is taken just before the feed is distributed to the various machines; it contains the original ore and the circulating middlings.

Q. 221. Now, take the column headed "Percent of Oil in Ore and Circulating Middlings Treated in Flotation;" that is determined by a correct assay of the material I presume?

A. It is.

3371 Q. 222. The same as in the case of the other tabulations?

A. Yes.

Q. 223. The next is simply computed from the percentage?

A. Yes.

Q. 224. You have a column here also, "Oil Used," with a series of numbers. Have you a key for those numbers which explains what the oil mixture is?

A. Yes, I run all my oil mixtures by numbers.

Q. 225. Does the key run through for the days on which the statement for January is made?

A. Yes.

Q. 226. It runs all through?

A. All through.

Mr. Scott: I offer paper headed "Butte & Superior Mining Company," with the notation below, "Statement of Percentage of Oils etc."

Admitted in evidence without objection marked Defendant's Exhibit No. 160.

Q. 227. You may explain the terms noted at the heads of the columns of oils there. What kerosene is that?

A. Commercial kerosene.

Q. 228. And the Jones crude?

A. That is Jones crude from Kansas; it is commercially called Jones crude.

Q. 229. The No. 1 creosote?

A. That is a hardwood creosote.

3372 Q. 230. The No. 2 creosote?

A. That is also a hardwood creosote.

Q. 231. Fuel, I suppose that means fuel oil?

A. Fuel oil from a petroleum base.

Q. 232. Pine oil next, No. 4 Barrett? What is that?

A. That is a coal tar distillate.

Q. 233. What kind of tar?

A Coal tar.

Q. 234. Paraffine base; what does that mean?

A. Crude paraffine base oil.

Q. 235. Now, I believe you have similar statements for February and March, giving the particulars for each day?

A. I have.

Q. 236. And the testimony you have just given regarding the explanation of these headings, and regarding your supervision of operations applies to these operations recorded in February and March?

A. Substantially so, yes.

Mr. Scott: I offer these statements in evidence for the months of February and March, 1917.

Admitted without objection, statement for February marked Defendant's Exhibit No. 161, statement for March marked Defendant's Exhibit No. 162.

Q. 237. I notice Mr. Dosenbach, that in January the average amount of oil added per day was 14.75, appearing at the bottom of the column in the average line.

3373 A. Yes, it is.

Q. 238. And that in February the amount of oil added per ton averaged 19.33?

A Correct.

Q. 239. Then considerable more was added in February than in January?

A. That is so.

Q. 240. Now, looking at the column "Pounds Oil Per Ton Con-

tained in Ore and Circulating Middling Treated in Flotation," which I understand is determined by assay, for February it averaged 23.6 and for January averaged 33.4. Why did the oil present exceed the amount added so much more in January than in February?

A. Well, as I stated before, that may be accounted for in the operation of the machines themselves, and also in the character of the oil that was used. Now, as will be noticed in the last column here, under oil used, and the number, you will note that various mixtures were used, and almost every day they were changed, consequently the difference in the character of the oils themselves may account for some of that variation between the two months.

Q. 241. Now, I believe you have operated a part of the flotation apparatus separate from the remainder for some periods of time. Have you a statement setting forth the operations of that segregated unit?

A. Yes, sir.

(Recess.)

3374 Q. 242. You stated that you had a sheet recording the operations of this independent unit, didn't you?

A. I have.

Q. 243. And I find attached to my copy a paper headed "Butte & Superior Mining Company" with the statement: "Below is a statement showing the percentage of oils in the various mixtures, used on the three pyramid machines, while running them on experimental tests," and I presume that bears the same relation to these separate machines that the other oil sheet did to the regular operations of the mill?

A. It does bear the same relation.

Q. 244. These experiments were conducted, were they, or these special operations by you or under your supervision?

A. They were.

Mr. Scott: I offer in evidence the tabulated statement headed "Butte & Superior Mining Company, flotation pyramid machines."

Tabulation admitted in evidence and marked Defendant's Exhibit 163.

Mr. Scott: And I wish now to offer in evidence what I will call the oil sheet, headed "Butte & Superior Mining Company," "Below is a statement showing the percentages of oils in the various mixtures, used on the three pyramid machines, while running them on experimental tests."

3375 Document admitted in evidence and marked Defendant's Exhibit 164.

Q. 245. What was the purpose of separately operating this section of the plant?

A. The main purpose and chief purpose was the fact that we didn't have sufficient oil to operate the entire plant.

Q. 246. With the quantities and kinds of oil you wanted to use?
A Yes, over one per cent or twenty pounds.
Q. 247. And what was the difficulty in getting a sufficient supply of these different oils?
A. Well, we had considerable difficulty in getting them on account of railroad facilities, it was impossible to get it here any sooner than on the 9th of January.
Q. 248. Was there any difficulty aside from the transportation difficulty?
A. Yes, one of the main difficulties was getting the oil.
Q. 249. Getting the oil?
A. Yes, being able to get it.
Q. 250. You mean there was not a supply available to be purchased?
A. Yes.
Q. 251. You might describe briefly what this separate section of the plant consists of, and in a general way how it was operated?
A. Well, this sheet or report sets forth the operations of an independent pyramid machine. There is a column where this
3376 machine number is shown and under it is the number of the machine that was in operation.
Q. 252. Now, when you say "pyramid machine" just what do you mean to designate by the word "pyramid"?
A. Well, the word pyramid is taken from the machine itself, it being a pyramid shape.
Q. 253. Simply similar to several of these machines of this Janney type, and each one higher than the preceding one, so that you have a gravity flow from one to another?
A. Exactly so, yes.
Q. 254. That is all that is meant by the word "pyramid"?
A. Yes.
Q. 255. And that is the regular arrangement of the entire plant, isn't it, that gravity or pyramid arrangement?
A. That is.
Q. 256. Now, under the column "machine number" on that first day, appears the figure "2." That is the number of the single machine or cell or the number of the whole set of these machines that are arranged one above the other?
A. That is pyramid No. 2 which consists of seven of the cells.
Q. 257. And each of these so-called pyramid machines consist of seven cells?
A. Exactly so.
Q. 258. And then each of these numbers in the column
3377 "machine No." indicates some particular group of seven machines that is being used for this test here recorded?
A. Yes, sir, it does.
Q. 259. So that all the tests were conducted on a machine consisting of seven Janney cells?
A. They were.

Q. 260. And they were these cells of the double spitzkasten type, weren't they?

A. They were.

Q. 261. Now, is there anything in these column headings that is different from the phraseology that you explained in connection with the other report?

A. Well, the first column, "machine feed," with the "ore to machines," that consists of a portion of the slime and a portion of the tube mill discharge.

Q. 262. Where do these slimes come from?

A. The slimes were regularly produced at the plant.

Q. 263. From the gravity concentration?

A. Gravity concentration end of the mill, and the tube mill product is the finely ground material that is produced in the mill itself or the concentrating end of the mill and is ground to sufficient size to go to flotation. It is sand tailing from the concentration end of the mill.

Q. 264. Now, in this column "machine feed" "ore to machines," "per cent zinc recovery," that percentage of zinc was obtained by assay, was it not, of the material fed, in this report?

3378 A. Yes, in this report, it was.

Q. 265. And so of course is true of the percentage of zinc in concentrate and headings, is it not?

A. It is. The apparent recovery is given but not the estimated recovery on account of not being able to obtain any definite weights or measurements of the concentrate produced.

Q. 266. That was because the concentrates were mixed up with the concentrates from the rest of the mill?

A. Yes, the concentrate produced in these machines was mixed with the regular concentrate.

Q. 267. And this "estimated recovery" is taken from actual weight?

A. It is.

Q. 268. Now under the general heading, "oil amount and analysis" we have a column "% oil in ore and circulating middling treated in machines." I presume that is obtained by assay from samples?

A. That is obtained by assay from samples taken.

Q. 269. After the——

A. (Interrupting.) Middling has been added to the original feed.

Q. 270. Yes, after they both come together?

A. Yes.

Q. 271. The next column simply converts the percentage into pounds?

A. It does.

Q. 272. "Per cent oil in concentrate" and "per cent oil in tailings" is found by what?

3379 A. By analysis.

Q. 273. The last column refers to the oil, kind?

A. Kind of oil used.

Q. 274. Now, is there a column here that tells how long these different operations lasted, or were they all for the same period?

A. They were for 24-hour periods on the days designated, and some days may have not been entirely 24 hours for the particular pyramid machine named if it was necessary at times to shut it down for repairs for an hour or two, possibly; but these are the actual results from these particular machines on these particular days and no other feed was put into that machine while it was not in operation on the material designated in this report.

Q. 275. The tonnages there give a pretty fair idea of the time that each operation was conducted, I suppose, don't they?

A. Yes.

Q. 276. I see some of these tonnages run up as high as 240. That is probably a 24-hour run, would you say?

A. Yes, that was a 24-hour run, I should say, judging from the tonnage.

Q. 277. Now, what was the largest percentage of oil used in any of these operations—we will take on the basis of pounds of oil added, say, rather than on the basis of the analysis?

A. I find in this report that on the first day of January, 1917, there was 63.03 pounds of oil added.

3380 Q. 278. Yes. Now, running over the column "pounds oil per ton in ore and circulating middling treated in machine" I find 58.8 pounds of oil per ton. That figure is somewhat lower than the amount of oil per ton of original feed added. What would that indicate in regard to the amount of oil on the middling?

A. That would indicate that there was less oil in the middling being returned.

Q. 279. Less than 63.03 pounds?

A. Yes, and that the returned middlings contained a lower percentage of oil than say on—other days. There are a number—there are a few days like that in the other reports, in the monthly report by days, that show that same thing.

Q. 280. What were your recoveries and grade of concentrate and loss of zinc in tailings on that day, January 1, 1917, when you used 63.03 pounds of oil per ton?

A. The recovery was 91.72 per cent, and the grade of concentrate produced was 42.7 per cent.

Q. 281. And the tailings?

A. The tailings contained 1.51 per cent zinc.

Q. 282. Now, were the concentrates from that tailing marketed?

A. They were.

Q. 283. What would you say as to the recovery of zinc—as to the loss of zinc in the tailings and the recovery, as to their efficiency? That is 1.51, is that a good or a bad operation?

3381 A. That is a good operation showing a recovery of over 91 per cent.

Q. 284. Now, do any of these other assays bring out any matters of interest that you wish to comment on?

A. Well, I should say, selecting one above that, on the first day of January, 1917, on a different pyramid machine, #2 pyramid, the tailings assayed .5 per cent zinc, one-half of one per cent, making a recovery of 97.18 per cent zinc, showing a concentrate of 44.6 per

cent zinc. I may add also here that the pyramid machines in operation as reported on this report consist of six cells and not seven, as the first cell was used as a cleaner.

Q. 285. What effect would that have on the operation?

A. Well, that would give six different agitations instead of seven, also six spitzkastens from which the froth was taken off, or twelve instead of fourteen, counting the double spitzkasten, or seven, counting the single spitzkasten, and also shows that there was only one cleaning operation of the concentrate that was produced by the rougher cell or the rougher pyramid consisting of six cells.

Q. 286. Did the concentrate from these specially operated pyramid machines have any further treatment?

A. They did not; they had no further treatment than the cells themselves, as far as these assays were concerned.

Q. 287. As far as the assays were concerned?

3382 A. Yes.

Q. 288. That is these operating assays that are here are from samples taken just when the concentrate left the pyramid machine?

A. Yes.

Q. 289. Now, what became of these tailings after they left the pyramid machine?

A. They went through the air cells down below, but they were mixed up with the tailings that were produced in other portions of the plant so consequently no assay could be determined after they left the air machine.

Q. 290. You didn't have any special air machine coupled up to this machine?

A. No.

Q. 291. About these other reports of general operations that you have testified about, are the tailing assays there made from tailings after they have gone through these air machines?

A. They were.

Q. 292. But in the case of these operations recorded on these special pyramids, the assay of tailings merely represents the tailings made by that pyramid?

A. Exactly so, yes.

Mr. Scott:

Q. 292½. I think that will be all unless you find something here that requires explanation, Mr. Dosenbach?

A. There is one thing I would like to explain about. In the January report by days for 1917, and that is on the 31st the apparent recovery was 87.12.

3383 Q. 293. What day was that?

A. On the 31st of January.

Mr. Williams: Exhibit 159?

A. Yes.

Mr. Scott: The apparent recovery you said was 87.12?

A. And the estimated recovery was 130.70. I think it would be

well to enlighten you on that particular date. Now, that is due to being the last day of the month and for our general reports and our general method in use, on the last day we take a general summary of what our products has been for the month as compared to each day's measurements, and consequently it shows an under estimating for 20—or the number of days previous to the 31st. Now, in addition to that, on account of not having sufficient railroad cars to transport our concentrates it was necessary to stack quite a lot of our concentrate on our grounds or bins provided for that purpose, after they had gone through the filter plant, and so some of this material was not taken into consideration in each day's calculation, or each day's measurement. Consequently, it was necessary for a general cleanup of the month to take into actual account all of the products for that month, and we had to take it into consideration on the last day. So that makes the difference between the estimated—or accounts for the difference between the estimated and apparent for the 31st of January.

Q. 294. That is this estimated recovery is figured from the
3384 absolute weights of the concentrates, and their assay?

A. From the estimated weight and assay, yes.

Q. 295. But some days that estimate was not based upon all the concentrates produced, and they accumulated during the month?

A. Yes.

Q. 296. So that the 31st day of the month got credit for some of the concentrates that had been produced previously?

A. Yes.

Q. 297. And to be absolutely accurate now I understand that some of this excess over one hundred per cent there or some of this excess should be distributed through all of these days, but that it is impossible to do it?

A. That is it exactly.

Q. 298. So that some of these estimated recoveries here are under statements, up to the 30th of the month?

A. Yes, it is more of a direct comparison, one day with another by the apparent recovery, but over a period of a number of days the estimated recovery should approximately check very closely with the apparent recovery.

Q. 299. The average for a considerable period would come close together?

A. Yes.

Q. 300. But on account of this accumulation of material why you couldn't figure out a comparison between individual days?

3385 A. Yes.

Mr. Scott: I think you may cross-examine.

Mr. Williams: Before commencing cross-examination I would like to say that we have been presented with tables of a number of experimental operations and have not had time to give them study and I would like to reserve the right to object to these experimental operations until we have had a chance to study them, being inclined to let them in if on further study we think they may be material.

Mr. Scott:

Q. 301. Mr. Dosenbach, these operations in this special pyramid machine, they were real, mill sized operations, weren't they?

A. Absolutely so.

Q. 302. They all entered into the product of the mill, which was marketed?

A. Yes, sir.

Q. 303. The only difference being that this part was separated for special operations?

A. As an independent and isolated circuit from the rest of the plant, but treating the same material as the rest of the plant did treat.

Q. 304. The concentrates were sold the same as all the rest of the mill?

A. Yes.

Q. 305. But it enabled you to keep track of the results without getting them all mixed up with the regular mill results?

A. Exactly so, yes.

3386 Cross-examination.

By Mr. Williams:

X Q. 306. Referring particularly to this table, exhibit 163. Now, "concentrates, percentage zinc," that was determined upon the concentrates after they had been delivered by the cleaner machine?

A. By the one cleaner machine which was on the pyramid that it represents.

X Q. 307. You say the first machine was the cleaner machine?

A. Yes, sir.

X Q. 308. By that do you mean the upper machine of the pyramid?

A. The first cell of that particular pyramid was the cleaner machine.

X Q. 309. And that was the highest machine of the three?

A. Yes, sir.

X Q. 310. So that the rougher concentrates from the other six machines were carried by an elevator, were they not?

A. No, by a pump.

X Q. 311. By a pump?

A. Pump, centrifugal pump. It was necessary to pump it back up to this first cell. The original feed came into the second cell while the rougher concentrates were made on the first two cells and the middling on the next four; or it was so arranged that the next three could make a rougher concentrate or middling, either
3387 one and that rougher concentrate was pumped back again to this first cell.

Mr. Scott: At this point, if I may interrupt, I would like to offer that in evidence so that it can have a number, and the record will show what you are referring to.

Diagram admitted in evidence and marked Defendant's Exhibit 165.

Mr. Williams:

X Q. 312. That is the flow sheet that was produced and described on Saturday last? Is that right, Mr. Scott?

Mr. Scott: Yes.

The Witness: Yes, that is the flow sheet that I produced and described on Saturday. However, I will produce another flow sheet to show exactly as the materials are going today. That doesn't show everything complete, but for this reference we can use.

X Q. 313. Now, I want to understand exactly the operations during these runs that are tabulated in Exhibit 163, and as I understand now on machines 2 and 3, you produce a finished concentrate?

A. Now, let me correct you on that. This is machine No. 1, and at that time this was machine No. 2, and at that time this was machine No. 8.

X Q. 314. As you have marked them in pencil?

A. Yes. Now the machines are numbered 1, 2, 3, 4, 5, 6, 7, 8 as I indicate, consequently the machine which is now marked No. 5 was at that time marked No. 2.

3388 X Q. 315. Now, cell No. 2 and cell No. 3 of that complete pyramid machine produced a finished concentrate?

A. They produced a rougher concentrate.

X Q. 316. And cells No. 4, 5, 6 and 7, what do they produce?

A. They produce a middling product.

X Q. 317. What became of the middling product?

A. The middling product was pumped back to cell No. 2.

X Q. 318. And the rougher concentrate was pumped where?

A. To cell No. 1.

X Q. 319. And from cell No. 1, then was delivered only finished concentrate?

A. Exactly so. The cleaner concentrates from cell No. 1 ran by gravity into cell No. 2. That is why we used cell No. 2, because we did not have to pump these cleaner tailings, because it ran by gravity into cell No. 2. That is the first cell handling original feed plus the middlings. The final tailings are made only by cell No. 7.

X Q. 320. I think now we have it all. The only final tailings are made by cell No. 7?

A. Yes.

X Q. 321. And the only final concentrates are made by cell No. 1?

A. Exactly so.

3389 X Q. 322. Your final concentrates from cell No. 1 are assayed, and your assays are based on that concentrate as delivered?

A. Exactly so.

X Q. 323. And the tailings also are from those tailings as delivered from machine No. 7?

A. From cell No. 7, yes, sir.

X Q. 324. And that applies to every one of these operations described in exhibit 163, is that correct?

A. That is correct.

X Q. 325. When did you commence work at the flotation plant of the Butte & Superior Mining Company?

A. About the first of May or thereabouts; it was in May, 1913.

X Q. 326. What kind of flotation machines were in use then?

A. The ordinary agitation and spitz box type, built entirely of wood.

X Q. 327. Were they substantially the same as the standard mineral separation plants?

A. What is the standard mineral separation plants?

X Q. 328. We have in evidence on pages 1030 and 1031 of the record in the Hyde suit, a drawing entitled "Complainant's Exhibit, King John's Court, Standard Plant." There is also on page 27 a cross section of that plant. Please look at those drawings and say whether or not they fairly in general represent the type of machine that was in use when you went to work for the Butte & Superior.

Mr. Kremer: Do you refer to the record in this court or in the Circuit Court of Appeals?

3390 Mr. Williams: To the record in this court, which is already in evidence.

A. No, I see quite a little difference to this which is represented here by the King John's Court Standard plant, and what was in use at that time at the Butte & Superior plant.

X Q. 329. Are there any resemblances?

A. Yes, there is a resemblance, as there are spitz boxes and agitating cells in this drawing, and there were also spitz boxes agitating cells in the plant of the Butte & Superior at that time.

X Q. 330. And in addition in the agitating cells was there a rotating agitator having blades located near the bottom of the cell.

A. There was.

X Q. 331. And the pulp that was agitated in the agitating cell flowed into the spitzkasten?

A. It did.

X Q. 332. And the froth from the spitzkasten overflowed?

A. It did.

X Q. 333. And the tailings went where?

A. The tailings were elevated to the next agitating cell.

X Q. 334. Where—Were these machines known by any name?

A. I knew of them by no name at that time.

X Q. 335. You did not know them as the Hyde machines?

A. Absolutely not. I didn't know Hyde at that time.

X Q. 336. Have you any drawing that you can produce

3391 showing these machines as they were then installed?

A. I can make one for you.

X Q. 337. Will you do that later on and let me have it?

A. All right.

X Q. 338. I note that for the first quarter of 1913, the apparent recovery of zinc was 65.34 and that for the second quarter of 1913 that same item was 85.71. That appears on exhibit 158.

A. You are correct.

X Q. 339. Can you explain why that great difference existed between the recoveries?

A. On April 25th the flotation plant was shut down for remodeling and changing over into a new system, which resulted in very much better recoveries after it was started up again—about a week or so later. You might say still that it might be due to the more oil being added; there was twice as much added during the second quarter as during the first quarter but I think it is due to the mechanical changes that were made which resulted in better operating conditions throughout in general.

Mr. Williams: I will ask of counsel of the defendant whether they will produce a witness who is familiar with the operations during that first quarter, in view of the fact that they seem to have been most disastrous operations, and this witness can not tell anything about them except from the record.

3392 Mr. Scott: We will furnish a witness, or two or three of them.

A. I was not present during that time.

X Q. 340. Well, I won't ask you about it. Now, covering the period of your experience, when was the next shut down for alterations?

A. Well, the shut downs came pretty frequently about then.

X Q. 341. Just run over them. Have you a record of them?

A. I have a partial record of them, and I find that during May of 1913 we did quite a lot of experimenting.

X Q. 342. What did you do in May; how many times did you shut down?

A. Well, I haven't that all here; I cannot tell you that; but the conditions, the mechanical conditions were such that it was necessary to shut down quite often to fix up the plant. We changed in 1914 from the method of handling the material from one spitz to the agitating cell, and put in pumps instead of air lifts, and in the second quarter we changed and added more additional spitzkasten, which assisted in recovering, and later changed to pumps on No. 2 roughers, having changed on No. 1 before. Then during the third quarter and last quarter of 1914 the arrangement of the flow through the cells was changed, so that, instead of making five passes, as you might call them, or having five cells, we had seven. So then, in the last of 1914 we started to excavate for the new Janney machines, and

3393 during the first quarter of 1915 these Janney machines were being installed, one by one.

X Q. 343. And that was the first installation of Janney machines at your plant?

A. Yes; and during the second and third quarter the Janney machines were completed, and the old machines were torn out.

X Q. 344. Were those the pyramid Janney machines that you have now?

A. No. Now, then, again, those Janney machines were torn out and the pyramid type put in. That was due principally to the original Janney machines not operating well on account of the

foundations. They were set upon concrete foundations, and the ground moved considerably up there, so that one machine was at an angle one way and the machine next to it was at an angle another way, and it was very nearly impossible to operate them; they had settled so much that they had to be entirely changed, and the pyramid was put in on wooden foundations, so that, if any more settling occurred, they could be brought back into shape again without having to tear up the whole plant and remodel.

X Q. 345. When did you put in the pyramid machines that are now there?

A. We started putting in the pyramid machines during the latter part of 1916, was the first ones, and that was the No. 2, which is now the No. 5. That was the first one that went in, because we had no other machine in that particular part of our flotation
3394 plant at that time, and we could install that without interfering any with the operations of the other machines.

X Q. 346. And then the other pyramid machines, when were they installed?

A. They were installed right along, following No. 2.

X Q. 347. So that when did you have the complete pyramid plant installed and operating?

A. It was in February or March of 1917, I am not positive which, but I can give you the exact date by looking up the record.

X Q. 348. Well, taking these records in Exhibit No. 158, do they enable you to fix the dates, or the time when the complete pyramid machine—pyramid plant was installed. You have divided it into periods.

A. Well, it was divided into periods on account of this report being kept up from time to time. This report was gotten out and later on more material was added to it; that is, when we had a period of sufficient length of time to add to it. But it was not until some time in February or March that we started the entire plant, or that the entire plant was operating on the pyramid type machines. It was after we had started using 20 lbs. or more of oil per ton of ore on the entire plant.

X Q. 349. Will you look up that date and let me have it?

A. I will.

X Q. 350. What is the reason for dividing this report as to 1917 into periods?

A. Well, as I say, this report was gotten up in 1917, and
3395 was gotten up as far back as the first part of March, showing the results as they existed in this report at that time. Then, after the 20th, this report was gotten out, showing the same material, but for the additional 20 days in March, and the 21st to the 31st and the first to the 15th, which was not on the original report.

X Q. 351. Taking the first period, December 22nd to January 7th, as to which you have supplied no details, why did you link that as a single period?

A. Up to that time we were operating the pyramid machines on more than 1% of oil and the rest of the plant on less than 1% of

oil, and after that time the entire plant was started on more than 1% of oil.

X Q. 352. Then during that period from December 22nd to January 7th you were operating a part of the plant on less than 1% of oil, but you do not include that in your report?

A. That is included in the third quarter of 1916. That is why the third quarter of 1916 is segregated from the average for the year 1916, on account of including from December 22nd to the 31st of December, when a part of the plant was in operation on more than 20 lbs.

X Q. 353. Now, from January 1st to January 7th, the operations with less than 1% of oil are not included in the report, is that right?

A. They are not included.

X Q. 354. When did you discontinue those operations with less than 1% of oil?

A. We discontinued them on—January 9th was the first
3396 day that we operated the entire plant on more than 1%.

X Q. 355. And from that time on were there any operations that were not shown in your report here?

A. There are no operations.

X Q. 356. What happened between January 20th and February 3d, 1917; were they included in one period—I can't quite read that; was that the intention?

A. Yes, it was, but the exact amount of oil that was added during that period was 16 lbs., which is a little less than 20 lbs., and we had no oil analyses of the machine feed at that time, which consisted of the original ore and the circulating middlings in flotation.

X Q. 357. Below that is that and the item, January 7th to February 6th, inclusive?

A. Yes.

X Q. 358. Does that include a run?

A. No, that includes the entire period for that time.

X Q. 359. Now that overlaps on February 4th to February 28th. Why are they overlapped?

A. Well, the correct oil analysis of the percent of oil in the ore and circulating middlings treated in flotation—we did not have it for that period entirely; that is the only reason that I know of why that is separated that way.

X Q. 360. So that the overlapping in dates which appears in those two periods was an actual overlapping, but you took February 4th as the commencement of the period, because you had certain determinations for that period, is that right?

3397 A. Yes.

X Q. 361. When did you commence to study the effect of larger quantities of oil than 1% in flotation concentration of ores?

A. I ran across that accidentally; I did not start to study that. That was in the summer of 1913, when I was sent to the Utah Copper to assist in determining what could be done down there with the flotation of their ores.

X Q. 362. Did you perform any experiments in the San Francisco Court of Appeals at the hearing in the Hyde case?

A. I did.

X Q. 363. What time was that?

A. I will have to look up the exact time on that.

Mr. Scott: It was February, 1914.

X Q. 364. It was February, 1914, I believe. And you say that you commenced to study the effects of larger quantities of oil at what time?

A. Well, as I said before, I was sent to Utah in July, 1913, and while down there I was endeavoring to see what could be done on the Utah Copper ore, and while investigating the possibilities of flotation at that time, as far as I knew of it, I found that in order to get results there, it was necessary to use quite a large quantity of coal tar or coal tar derivatives.

X Q. 365. Now, you are talking about experiments, aren't you?

A. Oh, yes.

X Q. 366. You performed experiments in this court on
3398 the hearing of the motion for a preliminary injunction, did you not?

A. I assisted in those experiments, yes.

X Q. 367. And then you performed experiments at Wilmington, Delaware, at the trial of the Miami case, did you not?

A. I did.

X Q. 368. And in the Supreme Court of the United States at the hearing of the Hyde case?

A. I did.

X Q. 369. And in the hearing at Philadelphia in the appeal of the Miami case?

A. I did.

X Q. 370. As I remember it, in the Miami case I asked you about how many experimental operations you had performed with large quantities of oil, and you gave me an estimate then of about a thousand; what is the present estimate?

A. Well, I don't know how I could estimate that. That is my general duty, to perform experiments and to investigate the possibilities of the various ores and oils, especially oils, and as there are many kinds of oils, why naturally the number of experiments that I have performed would run into a great number.

X Q. 371. Now, you performed an experiment in court with a machine alleged to be the machine described in the Criley Everson publication. Is that the same machine that was used in Wilmington, Delaware, in the trial of the Miami case?

A. It is not the same machine.

3399 X Q. 372. Is anything about it the same machine?

A. Substantially so, yes; it is similar to the one that was used there.

X Q. 373. Well, is there anything about it the same machine?

A. No.

X Q. 374. Is it a new machine?

A. It is not the same machine at all that was used there.

X Q. 375. It is a new machine, and it is different from what the machine was there, is that right or is it the same in construction?

A. It is substantially the same in construction as the one that was used in the Miami case.

X Q. 376. What difference have you made in the details of the construction in making this new Fryer Hill machine?

A. I have made no intentional differences whatever. There may be something slightly different in the construction, but it can not be the same machine, because the other machine is still in court.

The Court: You asked once about the Criley Everson and then about the Fryer Hill; are they both the same?

Mr. Williams: I made a mistake. The Fryer Hill.

X Q. 377. As you describe this old Fryer Hill machine, you said the central tube was hollow, and there was an opening, I believe, at the bottom of the tube, just above the cross blade agitators?

3400 A. Yes.

X Q. 378. What function did that hollow tube and that opening perform in the operation that was carried on in court?

A. It performed no function whatsoever.

X Q. 379. As I look at it now, there are two holes at the place indicated, diametrically opposite, and they are both of them nearly stopped up; do you agree as to that?

A. I haven't looked at it; I will inspect it and see. Yes, they are partly stopped up.

X Q. 380. When you rotated that cross blade agitator, in what manner did the inclined vanes on the bottom of that agitator operate, to throw the material outward or inward?

A. Outward.

X Q. 381. You performed an experiment which concluded with an upcast separation of the metalliferous mineral, which sank against the upcast, and you said that roughly speaking the percentage of oil to metalliferous mineral was about 7%; is that right?

A. It is.

X Q. 382. Can you give me the metalliferous mineral content of the ore that you used, having in mind that it contained not only blende but some other metalliferous mineral?

A. Well, I would have to have that analyzed before I could give it to you. I only paid attention to the zinc content, and based my figures upon the actual zinc and zinc sulphide content. However, I

3401 will give it to you approximately from my own knowledge of how the ores run.

X Q. 383. Well, you may give it approximately and correct it later if you are in error.

A. I will look it up and give it to you exactly.

X Q. 384. Well, then, give it to me exactly. Does the insoluble, as given in the assay, give you a figure which, if subtracted from the total, will give as the difference the metalliferous mineral?

A. I gave no insoluble assay.

X Q. 385. Well, is that so; that is, usually is that a fact?

A. It will give you very close to the amount of sulphide which is contained, which can be added to the amount of metal as determined.

X Q. 386. You said that you were familiar with the Everson patent, and that you find in the Everson patent authority for the use of sulphuric acid and copper sulphate together?

A. I did.

X Q. 387. Please point out in the Everson patent the part thereof which is authority for your statement about this, and read the part you refer to.

A. On page 1 of the Everson patent, line 87: "The acids which I have employed are sulphuric, hydrochloric, nitric, phosphoric, acetic, oxalic, tannic and gallic. I have also used the following salts, to-wit: the sulphates and chlorides of sodium, zinc and copper, and the double sulphate of potash and alumina." "The selection of the
3402 appropriate agents, will, however, be largely determined in the practical working of my invention by the consideration of economy, which will obviously exclude the greater number of those above enumerated."

X Q. 388. When did your knowledge of mining operations commence, or metallurgical operations?

A. Just what do you mean, a little more fully; I don't quite understand.

X Q. 389. Well, when did you first commence to study or practice metallurgy?

A. In 1906.

X Q. 390. While you were performing an alleged Fryer Hill experiment, I called your attention to the fact that the description of the ore in that experiment was as follows: "The ore was first crushed and rolled to such a degree of fineness as to enable it to pass through a forty mesh screen?" And then I asked you about the material that you were using in that experiment. Now, in the first place give me the screen analysis of that material?

A. I can't give you a screen analysis of that material, but I can give you a screen analysis of some of the same materials, of which I have made a screen analysis.

X Q. 391. Which you believe will be substantially the same?

A. It will.

X Q. 392. All right.

A. On a 65 mesh or plus 65 mesh, 2.21 per cent; + 100
3403 mesh, 8.03 per cent; + 150 mesh, 9.24 per cent; + 200 mesh, 19.48 per cent; — 200 mesh, 61.04 per cent. That is approximately what the other would be.

X Q. 393. Did it go any finer than that?

A. I have nothing finer than 200 mesh.

X Q. 394. Will you, as a metallurgist, stand for the proposition that this material that you used is a material such as was described in the Fryer Hill publication?

A. I will. My reason for doing so is that the Fryer Hill publications stated that that ore was crushed and rolled to pass a 40 mesh screen; and anyone familiar with the operation of rolling, crushing will know that in order to crush the ore equal to a 40 mesh screen

that there will be a great proportion of fines made on account of the method of feeding the rollers, which will be a choke feed, and there will consequently be a great amount of fines made.

X Q. 395. Now, have you the record of the daily operations at the commencement of your work with the Butte & Superior Copper Company?

A. I haven't the daily record tabulated as I have done in 1917.

X Q. 396. But you have a daily record which will give the information?

A. Yes.

X Q. 397. In what form is it?

A. Why, I have the daily record in report form; that is in daily reports which include the assays of the headings, the mill—
3404 the general tailings, concentrates, flotation as produced by the mill and the amount of reagents used and the tonnage treated.

X Q. 398. Well, will you let me see the record for the first months that you were there?

Mr. Williams: While waiting I will hand up an affidavit of Mr. Ballot covering those matters in relation to the proposed supplemental bill of complaint which we were discussing.

A. It will be necessary for me to give you the date. The record for the first month I was there, I have got to go farther back than that because this report does not begin until the last of 1913.

Mr. Williams:

X Q. 399. These are the earliest that you have?

A. Of this year. It will be necessary to go back and get the assay sheets, each individual one, and get the material from those.

X Q. 400. Well, now, take the first day that you have a record of here?

A. All right.

X Q. 401. What is that day?

A. November 1, 1913.

X Q. 402. Now, this table that you have produced is the original record of the company, is it?

A. This one?

X Q. 403. Yes, this table that you have here?

A. Yes.

X Q. 404. That is the original record of the company and not a copy, it is a record of the company? Is that right?

3405 A. Yes, that is correct, yes.

X Q. 405. And from it you have no tabulations wherein the days are brought together?

A. From it we have monthly statements, yes.

X Q. 406. But no daily statements other than these?

A. Well, it don't include all the information that this does.

X Q. 407. Well now, how many—what was the first item of that statement?

A. The first statement—the first item is ore received, dry tons for the day. The total to date, and the last of the month.

X Q. 408. Well, for the day 1,193 tons?

A. Yes.

X Q. 409. And then what is the next heading or column giving tons, 1,181?

A. That is the amount of ore that was milled for that particular day.

X Q. 410. Now, give me the assay of concentrates produced on that day?

A. The zinc concentrate produced, dry tons, was 377.

X Q. 411. Now, give me the zinc content of these concentrates?

A. 50.5.

X Q. 412. And the amount of the tailing?

A. The zinc content of the tailings?

X Q. 413. No, the amount of the tailings?

A. Well, I would have to calculate that first.

3406 X Q. 414. Well then, never mind. The zinc content of the tailings?

A. 3.1 zinc.

X Q. 415. Now, that figure as the zinc concentrate, is that the zinc concentrate of the flotation plant or the total zinc concentrate of the mill?

A. Below here we have the zinc concentrate, zinc content of the concentrate that was produced by the mill, then also by the flotation plant separately by shifts.

X Q. 416. Will you give me that mill zinc concentrate on the first shift that day?

A. That was 52.8; the second shift 53.0, and for the third shift 52.3. The flotation concentrate for the first shift was 49.7; for the second shift 49.5 and for the third shift 49.6.

X Q. 417. I notice a line giving the dilution of the flotation feed. I suppose that is the proportion of solids to water?

A. That is the proportion of the water to the solids, yes, sir.

X Q. 418. Just give me that figure?

A. The first shift, 2.4; second shift 2.3; third shift 2.4.

X Q. 419. Now, give me the amount of oil used, first, flotation oil pounds?

A. 1,429 pounds the first day, which was equal to 1.209 pounds per ton.

X Q. 420. And whose signature is signed to that sheet?

3407 A. F. R. Wicks, mill superintendent.

X Q. 421. And that is the F. R. Wicks who has testified in this case, is it not?

A. That is the F. R. Wicks.

Mr. Garrison: I offer in evidence the following documents delivered by the defendant in response to our call, and ask that they each be admitted in evidence and marked with their appropriate number.

Mr. Kremer: To each of the documents offered in evidence the

defendant objects for the reason that it is incompetent, irrelevant and immaterial, and tends to prove no issue in the case and it is particularly incompetent insofar as the alleged issue of estoppel or res adjudicata is concerned in that no evidence has been introduced or offered which in its nature is of such a character as to constitute estoppel or res adjudicata as against this defendant; and for the further reason there is no sufficient issue of estoppel or res adjudicata raised by the pleadings.

The Court: These are part of the same matters to show payment?

Mr. Garrison: Yes, sir.

The Court: The same ruling. The objection will be overruled and exception will be noted.

Mr. Kremer: An exception should be noted to each of the exhibits.

Whereupon the following documents were admitted in evidence and marked with the respective exhibit numbers shown in connection with each.

Voucher No. 3409, amounting to $165.00 issued to J. M.
3408 Hyde under date of July, 1911, admitted in evidence and marked Defendant's Exhibit 166.

Voucher of the Butte & Superior Copper Company No. 3495, amounting to $155.00, in favor of J. M. Hyde, August, 1911, admitted in evidence and marked Defendant's Exhibit 167.

Voucher No. 3508, amounting to $150.00 issued to J. M. Hyde under date of September, 1911, admitted in evidence and marked Defendant's Exhibit 168.

Voucher of Butte & Superior Copper Company No. 3519 amounting to $150.00, in favor of J. M. Hyde, September, 1911, admitted in evidence and marked Defendant's Exhibit 169.

Voucher of Butte & Superior Copper Company, No. 3584, amounting to $150.00, in favor of J. M. Hyde, under date of September, 1911, admitted in evidence and marked Defendant's Exhibit 170.

Voucher of Butte & Superior Copper Company, No. 3610, amounting to $5,000, in favor of J. M. Hyde, October, 1911, admitted in evidence and marked Defendant's Exhibit 171.

Voucher of Butte & Superior Copper Company, No. 3609, amounting to $150.00, in favor of J. M. Hyde, October, 1911, admitted in evidence and marked Defendant's Exhibit 172.

Voucher of Butte & Superior Copper Company, No. 3764, amounting to $230.15, in favor of James M. Hyde, November, 1911,
3409 to which is attached a paper headed "Expense Account, Chicago Trip, J. M. Hyde," admitted in evidence and marked Defendant's Exhibit 173.

Voucher of Butte & Superior Copper Company, No. 4153, amounting to $369.47, in favor of J. M. Hyde, March, 1912, admitted in evidence and marked Defendant's Exhibit 174.

Voucher of Butte & Superior Copper Company, No. 4154 amounting to $400.00, in favor of J. M. Hyde, April, 1912, admitted in evidence and marked Defendant's Exhibit 175.

Check of Butte & Superior Copper Company, dated July 8, 1912,

payable to the order of J. M. Hyde for $200.00, to which is attached voucher of the Butte & Superior Copper Company, No. 4550 for the same amount and bearing the same date, admitted in evidence and marked Defendant's Exhibit 176.

Check of the Butte & Superior Copper Company under date of November 21, 1912, payable to James M. Hyde, for $602.50, to which is attached two lead pencil memoranda and a letter on the letterhead of Hayden Stone & Company, Bankers, New York-Boston, bearing date New York, October 3, 1912, addressed to Mr. M. W. Atwater, Butte & Superior Copper Company, Butte, Montana, consisting of two pages, a typewritten sheet headed "Expense account of James M. Hyde, trip to Washington Patent Suit, leaving Butte, April 17th, 1912, amounting to $334.05, another typewritten
3410 document headed "Expense account of James M. Hyde, Trip to London, on Patent Suit, leaving Butte, July 18th, 1912," amounting to $868.45, and voucher of the Butte & Superior Copper Company under date of November 21, 1912, payable to the order of James M. Hyde, No. 5333, amounting to $602.50, admitted in evidence and marked Defendant's Exhibit No. 177.

Letter on the letterhead of the Butte & Superior Copper Company, under date of July 31st, 1913, addressed to Mr. J. L. Bruce, Manager Butte & Superior Copper Company, Limited, Butte, Montana, signed by N. B. MacKelvie, and a purported copy of letter bearing date Berkeley, California, July 30th, 1913, addressed to N. B. MacKelvie, signed James H. Hyde, admitted in evidence and marked Defendant's Exhibit 178.

Whereupon an adjournment was taken until 8:00 p. m. of this day, Monday, April 30th, 1917.

3411 8 o'clock p. m. April 30, 1917.

Mr. Sheridan: If the court please, I think I would like to have Prof. Taggart give a resume of the fact which the pictures of the froths will show.

Professor TAGGART, recalled.

The Witness: This is a drawing, similar, I think, to a drawing that was made the other day to show the situation of affairs at the surface of an air bubble in an oil contaminated pulp, containing sulphide mineral.

Q. Something like defendant's exhibit No. 128?

A. Yes. There is a bubble of air surrounded directly at the air-liquid contact with an oil rich layer, which grades in concentration from maximum oil concentration at the air-liquid surface to maximum water concentration removed away from the air-liquid contact. Then at the surface of the bubble, but not piercing the bubble so as to be in contact with the air, are the sulphide particles. Now, these for the photographs which we will show tonight will show some bubbles in that condition, with particles of sulphide sticking to the outside of the bubble. They will also show some of the bubbles that

have emerged from the liquid and are found in the condition of air on one side of the bubble film, air in the other side of the bubble film, and the sulphide particles contained completely within the film, but at no place in contact with the air.

3412 Now, a proof of this particular contention, that the sulphide particles are at no place in contact with the air, is shown beautifully by some of the bubbles which are directly against the glass through which they were photographed in the froth. Those bubbles, in moving up along the glass, have been rubbed free of the sulphide particles by the mechanical moving along the glass, so that they present the appearance of those bubbles that the court saw this afternoon, that were not coated, which were in contact with the glass. Those bubbles may, however, be coated at other places where they are not in contact with the glass. Now, that means, that if you look through this side of the bubble it is clear along the glass, and as the photographs were taken the camera was at a point such as this (indicating) and the light was coming from a point such as this (indicating) and from those clear bubbles there will be noticed two reflections of that light, one from this surface of the bubble and one from this surface. I think that can be illustrated rather well by looking at the reflection of light, here with this water bottle; there are two reflections of that light, one from the concave surface and one from the convex surface. Now, we will get exactly the same condition in some of the bubbles that are clear in contact with the glass in the photograph which you will see. The fact that we get those two reflections is a proof of the fact that there are no sulphide particles on the back of that bubble, sticking through into contact with the air, because if there were particles on the back of the

3413 bubble sticking through into contact with the air, then the back of the bubble would be dull, and would be a non-reflecting surface. I think I can show it with a rough diagram. If this represents a smooth reflecting surface and this is the source of light, and the eye is here, the gleam of that light will be recognized by the eye from this particular angle, and the angle which the beam of light makes with the plane, that is the angle A, will be equal to the angle at which the light goes to the eye; in other words, the angle of instance of the light is equal to the angle of reflection. Now, if we take a surface rough and corrugated in that fashion, the beam of light will go in the same way, but no beam of light will be recognized by the eye at this point: there will just be a general illumination, due to the diffusion on the rough surface. If the back surface of the bubble in the pulp were in this condition, as it would have to be if the bubble stuck through into contact with the air, then there would be no second reflection from the back of the bubble, but merely the one reflection from the front of the bubble that is clear and in contact with the glass.

I have represented here the rays of light as they will be reflected from the outer surface of the bubble and the rays of light as they will be reflected from the inner surface of the bubble to the eye. I think that is all, as far as that particular phase is concerned.

Prof. Taggart: Now, the pictures will also show that it is
3414 impossible, by visual examination, to tell whether a froth has been made with more or less than one per cent of oil; and that will further show, as more or less of an incidental feature, that it is possible by the eye to tell and distinguish in froths—in some froths at least—provided these froths have been made with different oils, but with the same oil less than one per cent of oil and more than one per cent oil, is impossible to tell from the photograph.

Mr. Williams: These sketches should be marked as exhibits.

Mr. Sheridan: I will introduce them now. This first sketch referred to by Prof. Taggart, his diagram No. 22, we offer in evidence.

Diagram Taggart's No. 22, admitted in evidence and marked Defendant's Exhibit 179.

Mr. Sheridan: And then the second one will be offered.

Taggart diagram No. 23 admitted in evidence and marked Defendant's Exhibit 180.

Mr. Sheridan:

Q. When the pictures are put on the screen first, Mr. Phillips will give us an idea of about how large the magnifications will be on the screen, how large the increase in diameter will be of the lantern slide, and then the relative size of the magnification upon the screen.

Mr. Phillips: Some of the photographs were magnified—
3415 one series of photographs were taken natural size and in making the lantern slides from those photographs they are reduced on the lantern slides and the photograph of the top of the film which are natural size, the slides are reduced to 7-11 diameter, 7-11 of one diameter. The photographs that are magnified five diameters on the lantern slide are reduced to 2 3-10 diameters; and the photographs that were magnified 15 diameters are reduced to 6.9 diameters—that is on the slides. Now, in projecting these slides, the picture on the slide is two inches wide, and we make the image of the slide and thus magnify the picture on the screen in inches, divide that by two; the width of the image in this case is three feet. That will be 36 inches. Divide that by two and then the magnification by the projection is 18 diameters and multiply the 18 diameters by the magnification on the slide in whatever case it will be and that will give the diameters of the magnification of the image, and then by squaring these diameters it will give you the number of times that the picture is magnified. The pictures of the top view are magnified on the screen under these conditions 120 times, that means about eleven diameters. The series of pictures marked No. 2, that is the photographs magnified five times are magnified on the screen 1700 times, a diameter of about 41. And the fifteen magnifications are magnified on the screen 17,000 times, 1302 diameters. Now there are a number of slides of bubbles and the bubbles are of different dimensions and different magnifications, and that

3416 large magnification will be 375,000 times on the screen, and the first five slides of bubbles will be magnified 64,000 and the other one will be magnified 72,000 times.

Mr. Williams: Will you just go into detail a little about these magnifications?

Mr. Phillips: "Diameters" is lineal measure, and then the number of times magnification represents the area or square. You square the diameter to get the times.

Mr. Sheridan:

Q. Mr. Phillips, will you please tell us when a picture is thrown on the screen the particular oils that were used and the thickness of the froth? The first number indicates the index of the particular picture; the second number, say 1, 2, 3, as to whether it is the top view of the side or the magnified five diameters or the side one magnified fifteen diameters. They are repetition, these slides are replicas of the pictures that were put in evidence but we want to put the slides in evidence so they can be shown to the court more thoroughly.

Mr. Phillips: That is froth from oil mixture No. 3, and the froth was a quarter of an inch thick.

Mr. Sheridan: Professor Taggart will make a technical—any technical explanation he sees fit on each picture as put on the screen.

Prof. Taggart: I would like to have the court notice here chiefly that these bubbles are very similar in appearance to those that we saw through the microscope the other day. These represent bubbles

3417 which have air here on the upper side, the atmosphere, and upon the inner side some of the air that was beat into the pulp and has risen with this and other bubbles which have combined to form the big bubble, but the particles of mineral are within the film itself. The film raises smoothly and regularly over the particles; there are no jagged projections which would be characteristic of a mineral particle sticking through into the air. There you notice also that the froth is rather sparse in that particular particle. This represents the same froth magnified five times. The upper line of the froth comes along in about here (indicating).

Mr. Phillips: 120 times that is.

Prof. Taggart: think that is all of that.

Mr. Sheridan: I wish you would put that screen back again. I would like to have Prof. Taggart direct the court's attention to the hanging particles at the lower part of the froth.

Mr. Taggart: Yes. These are the particles. Of course on these froths that are made in the machine where the froth is not removed as rapidly as it is made, that represents the overloaded bubbles which gradually become so heavily laden that the buoyancy of the air within the mass of bubbles is not sufficient to buoy up the particles. Such a condition is not characteristic of froths that are being removed continually, and is a characteristic in the small machines where the mineral—where there is plenty of mineral present with small quantities of oil as it is with large quantities.

3418 Mr. Williams: What is the percentage of oil in that froth?

Mr. Taggart: The percentage is one tenth of one per cent, isn't it, Mr. Phillips?

Mr. Phillips: Yes.

Mr. Kremer: The upper part of this shows the film on the glass.

Mr. Taggart: Oh, yes, just the contamination and dirt, and that will be observed on all of these froths that represent a magnification of five diameters. That is the upper line of the film. We get this in all cases above the top of the froth, a contamination on the glass which can be distinguished from the froth.

Now, you will notice here in this particular slide which is a projection magnified some thirteen hundred diameters the small particles plastered all over the outside of the bubbles. This mass through here represents similar bubbles of—similar bubbles very heavily coated with the solid particle. You see here these bubbles are under the water so that you are looking from the water side, from the pulp, as it were, against the bubbles, and consequently looking directly at the solid particles themselves. Now, as these rise to the surface and come out into the atmosphere, then the film has air on both sides and these particles are then wholly within the film.

Mr. Phillips: That is oil mixture No. 3, 0.3 per cent.

Mr. Taggart: This is 0.3 per cent; the former was 0.1
3419 per cent. You will notice that there are more bubbles, the whole surface of the jar is covered in this case with bubbles. The bubbles are larger and characteristic of the froth that are obtained from the later cells of the flotation machine as they are operated in the mill, that is the solid, while the mineral has become impoverished, and the pulp has become impoverished of some of its oil. This represents the same froth magnified in the picture some 41 diameters. You will note here the presence of an enormous number of small particles. These are plastered on the outside of the bubbles and some of the bubbles can be seen in a very rough fashion here. The characteristic appearance of the bottom of the film—of a film made in one of these square glass jar machines is noticeable here, and it will be noticed a dropping is shown about the same as it was in the froth made with the smaller quantity of oil.

Here is some froth magnified 130 diameters. Now, here you will notice the reflection that I speak of, here and here and here, where these bubbles which have been or are in direct contact with the glass walls of the cell, and they have been rubbed free of the load of solids that was on that particular surface, and the material has been distributed around here. It will be a little more noticeable, the particular distribution of the load of mineral on some of the other bubbles, but you will notice here is one of the reflections from one of the surfaces of the bubble, and here is the reflection of the other surface of the bubble.

3420 Here are the two spots of light, and here and here, and in all these it will be found that you have two spots of light, one reflected from the smooth outer surface of the bubble and one reflected from the smooth inner surface of the bubble.

Mr. Phillips: That is .4 of 1% oil mixture.

Mr. Taggart: Now, this froth is considerably heavier than the preceding ones. Your honor will notice the drawing back of the bubble film where the bubbles are broken here and here, the extremely viscous condition of that film, due to the intrusion of the solid matter. I think your honor noticed that in one of the froths this afternoon. The characteristic appearance of these surface bubbles is again apparent here. There is absolutely no sign here of a particle projecting from the bubble film, the films in that case rising smoothly from the particles, and the same is true, as was shown under the microscope of the other side of the film; that is, under the microscope the two sides of that film were absolutely indistinguishable. It was a type, and it showed the surface in contact with the air, and there is air of course inside of this bubble. Now these bubbles in the side view have but one side in contact with the air, and the side that we see is the side that is in contact with the water, and consequently there the particles are not included within the film, because the film as a film is not yet formed, but merely that the oil rich layer at the air-liquid contact with solid particles held in that oil rich layer and being brought to the top. As soon as they
3421 emerge into the top then they are entirely inclosed.

Here is a magnification of some 41 diameters of the same froth. You will notice here the bubble outlines, and see again this still characteristic fringe at the bottom.

Here is the enlarged view of these bubbles in contact with the glass, showing the two spots, the reflection from the outer and the inner surface.

Mr. Phillips: One half of one per cent. oil mixture.

Mr. Taggart: This is the same oil only a greater amount, and on the surface of course it is possible to distinguish the froth produced by one-tenth or two-tenths or three-tenths of 1% from the froth produced from oil five-tenths of 1%, because in the lower quantities the froths are so starved with the small quantity of oil that they did not completely cover the surface, but from now on the froths will be sufficiently voluminous to completely cover the surface of the jar, and from now on it is absolutely impossible to distinguish between them. You will notice here again this viscous film to which your attention was called in the last picture, and again the particles are wholly within the film.

This is a magnification 41 times, again with its characteristic fringe at the bottom.

Here the magnification is 130 times with the bubbles showing generally in contact with the glass, clear and showing two
3422 spots. Now you will notice upon this bubble that some of the solid matter has been rubbed off of the surface and that is seen on the bubble at the point where it is in contact with the glass, and of course this solid matter extends all around the surface of the bubble, except this small point or area that is in contact with the glass.

Mr. Phillips: 0.6 of 1% oil mixture.

Mr. Taggart: Here is the same oil, slightly more of it, and the same characteristic appearance absolutely.

This is a side view, looking through the glass, 41 diameters. The outline of the bubble here, and the fringe again at the bottom.

Here is a larger magnification.

Mr. Phillips: This is 1% of oil mixture.

Mr. Taggart: I don't think that there is anything peculiar about this to comment on; I have been saying the same thing over and over again about these as we went along. This is 41 diameters.

This is 130 diameters.

Mr. Phillips: 1¼% of mixture.

Mr. Sheridan:

Q. Point out those viscous films again.

A. Here are the bubbles which have broken this way, and have drawn back. The persistence of course of these films as a sort of sheet is a sign of their high viscosity.

Here is the same film magnified 41 diameters. Here again, magnified 130.

Q. You see some of those birdseye bubbles there?

3423 A. I see the spots in here just the same.

Mr. Phillips: This is 1½% of oil mixture.

Mr. Taggart: Here again the film is so like those that were shown before that it is useless to point out the particular characteristics.

This is a magnification 41 diameters. You notice that the fringe at the bottom is no more pronounced than it was on the lower quantities of oil.

Here is the high magnification with these characteristic bubbles showing the reflection from the front and the back surface.

Mr. Phillips: This is one-tenth of one per cent. eucalyptus oil.

Mr. Taggart: There you can see a decided difference from the one-tenth of one per cent. of this so-called oil mixture. You will remember that in the one-tenth of one per cent oil mixture there were bubbles around covering the surface with the exception of an area which would be included about where my pointer has passed. Here the bubbles are so scarce that the surface presents the appearance merely of a broken scum as it were, on the surface. These dark spots represent where bubbles have broken, and the surface is not covered with solid matter; in other words, you can see the water at those points.

Mr. Williams: It should be noted here on the record that this froth was produced with California eucalyptus oil, which has never been used in the flotation process, and it was not made with the Australian eucalyptus oil which has accomplished such wonderful results.

3424 Mr. Taggart: This is the side view of that particular froth of which we just had the top. Here you can see that there was a slight froth which was apparent at the surface.

Mr. Williams: Do you know where the line of that froth ends?

The Witness: About here.
Mr. Sheridan: Just above the bubbles?
A. Yes.
Q. How is the characteristic fringe, pronounced or not?
A. It is rather pronounced.
Here is the same froth magnified to the high diameter.

Mr. Phillips: This is five-tenths of one per cent. California eucalyptus oil.

Mr. Taggart: Your honor will notice here a very decided difference between this particular froth and the froth that was formed with the five-tenths of one per cent oil mixture; in other words, it is quite easy, not to say the particular oil with which a froth was made, but with many froths, to tell that they were made with different oils. However, given the same oil and varying, not the conditions but the quantity, then the problem of distinguishing the froth is an impossible one, visually.

Here is the magnification 41 diameters of the froth which has just been shown. The upper line of the froth runs through in some such position as this; I think it probably runs up a little like this, with this bubble rather up in the corner.

3425 Here again we have the characteristic two spots reflected from the bubbles whose surfaces are in contact with the glass or film.

Mr. Phillips: This is 2% eucalyptus oil, and the mineral in this case is chalcopyrite and silica. This is a side view, 41 diameters.

Mr. Taggart: We do not have the top of that froth?

Mr. Phillips: No.

Mr. Taggart: There is an apparent difference in that froth from the others that we have seen, due, evidently to the different mineral and to the great quantity of mineral in the froth. There is some froth there which shows the bubbles in contact with the glass, but they have not been sufficiently agitated, or they are too heavily loaded with the particles to rub them clean, so that we do not get the reflected surfaces as before. The white dots in these bubbles represent the reflection from the surface of the sulphide minerals. You will notice that the type of the reflection here is very different. On the other bubbles the reflection unquestionably was not mineral, because mineral does not distribute itself in this fashion on the bubbles. Here the promiscuous distribution of the mineral on the bubbles is not a similar case at all.

Mr. Phillips: This charge was made up according to the California Journal of Technology, mechanically mixed.

Mr. Taggart: Here again we have an obviously different appearing froth from either of the two previous froths, the difference

3426 being due, however, to the fact that different ingredients were used in forming the froth, not that different percentages of oil were used.

There is the side view of the same froth, magnified 41 diameters. Here is the highly magnified view, 130 diameters.

Mr. Phillips: This was the same charge, only it was mixed by hand in a mixing bottle.

By Mr. Sheridan:

Q. Just as it was on the judge's desk?

Mr. Phillips: Yes.

Mr. Taggart: The white streak down here is a reflection from the rounded surface of the bottle. The other photograph was taken in a square jar.

This is the same highly magnified, 130 diameters.

Mr. Phillips: These are bubbles of one-tenth of one per cent. eucalyptus oil.

Mr. Taggart: These are very much more magnified than any of the previous ones, are they not?

Mr. Phillips: They are magnified 64,000 times, 252 diameters.

Mr. Taggart: These were made by taking some of the froth from the machine and placing it in a small tube about one-eighth of an inch inside diameter, and then filling the tube up with water and corking both ends, so that the bubbles were completely immersed in water, and the tube was laid on its side and photographed. You will notice here even more distinctly than in the other pho-

3427 tograph, the rough appearance of the outside of this bubble. These are the solid particles stuck onto the outside of the bubble, inclosed within the oil rich adsorption film at the air-liquid contact surface.

Mr. Williams: What is that bubble at the upper right hand corner?

Mr. Taggart: Perhaps Mr. Phillips can tell us if he recollects the particular appearance of that. He probably does not. You see these are magnified 250 times, Mr. Williams.

Mr. Phillips: 252 times.

Mr. Taggart: So you don't notice a particular spot one-two hundred and fiftieth of that size?

Mr. Phillips: That is a bubble with no mineral, water on that face, directly in contact with the glass.

Mr. Williams: Were those bubbles up against a glass surface?

Mr. Phillips: Yes, they were.

Mr. Williams: So that they are a little bit flattened?

Mr. Phillips: Not very much; they probably are a little flattened.

Mr. Taggart: They were against a round surface; they are contained in a glass tube about one-eighth of an inch inside diameter.

Mr. Sheridan: In that upper right hand corner are those the characteristic two high lights?

A. They look like it, but I would not care to say.

Mr. Phillips: No, they are not.

3428 Mr. Williams: I think I can see about four, myself.

Mr. Taggart: I think so; I would not want to say about those; I think there are several.

Mr. Williams: What is that in the upper left hand big bubble, that dark space in the middle with spots in it?

Mr. Taggart: I think very likely that is the place at which the

bubble is in contact with the glass, and the solid has been abraded away at that point. I looked at some of those bubbles under the miscroscope, but not quite as high a magnification this morning, and that is quite a characteristic appearance, as this is also, where that particular bubble has been bumped at that particular place, and the mineral has been moved over and moved back here.

Mr. Phillips: These are bubbles taken from a charge containing one-half of one per cent. eucalyptus oil.

Mr. Taggart: And the previous one was how much?

Mr. Phillips: One tenth of one per cent. These are the same magnification.

Mr. Phillips: These are the same magnifications.

Mr. Taggart: Note the difference in the appearance of these bubbles.

Mr. Phillips: These are bubbles taken from a charge containing 0.1 per cent of mixture No. 3 magnified the same, 250 diameters.

3429 These are bubbles taken from a charge containing 0.5 per cent oil mixture No. 3, 250 diameters magnified.

Prof. Taggart: You will notice the characteristic two spots in these various bubbles, that are observable.

Mr. Williams: Those are air bubbles, aren't they?

Prof. Taggart: They are not completely clear, Mr. Williams, but there isn't a particularly heavy load on them.

Mr. Phillips: They are air bubbles separated from the water in part.

Mr. Williams: To my mind they are clear bubbles, showing similar reflected surfaces.

Prof. Taggart: Similar reflected surfaces, certainly, to those that we had before.

Mr. Williams: They have no metal in them?

Mr. Taggart: Some of them have. I noticed this morning in this examination that I spoke of that those particles are very lightly loaded—this is, most of them. I could not say all because I was not looking to see whether all of them bore a load, but most of these bore a light load of mineral. Of course it was not nearly so heavy a load as was borne by the big particles.

Mr. Phillips: That is a mixture containing one and one half per cent of oil mixture, magnified 250 diameters.

Mr. Taggart: And the previous one was how much?

3430 Mr. Phillips: 0.5 per cent.

Mr. Taggart: I would like your honor to look closely at this and then we will go back to the previous one, for this one is 0.5 per cent above the line and the other 0.5 per cent below. Except as a matter of different illumination it seems hard to note any distinction between the two slides.

Mr. Phillips: This is the same mixture, same kind of bubble, 1.5 per cent of oil mixture.

Mr. Sheridan: Enlarged how many times?

A. 64,000.

Mr. Williams: 64,000.

A. 252, as before.

Mr. Williams: 250 diameters.

Mr. Phillips: 250 diameters. This is a bubble from a charge containing two per cent of eucalyptus oil and the magnification is 612 diameters or 375 thousands.

Mr. Taggart: And a different mineral is used there.

Mr. Phillips: And the mineral is chalcopyrite and slicia.

Mr. Taggart: I think the difference here in the appearance of the bubbles is largely a question of the mineral.

Mr. Phillips: I would like to state that that bubble is interesting. In fact, in putting this bubble in and putting the cork on top, they put too much pressure and they condensed the air bubble and the coating of the bubble was ruptured and it was so well formed that it very nearly retained its shape.

3431 This bubble is from a charge containing two per cent eucalyptus oil, the same mineral, chalcopyrite and silica and magnified 270 diameters or 72,000.

This was wood tar oil 0.1 per cent, Butte & Superior ore.

Mr. Taggart: Here again you see these charactertistic two spots on these bubbles in contact with the side of the cell, it being borne in mind that these are photographed under water.

Mr. Phillips: That is wood tar oil 0.3 per cent.

Mr. Sheridan: What ore?

Mr. Phillips: Butte & Superior ore.

Mr. Taggart: And note that the froth is very sparse. That represents about the upper line of the froth on this particular picture. The part above is the dirt on the sides of the cell. Here we have the higher magnification with the same froth.

Mr. Phillips: This is 0.3 per cent wood tar oil, Butte & Superior ore.

Mr. Taggart: Again the surface of the froth shows very clearly the characteristic bubbles. The flattened effect between the—The flat effect, although the complete surface of the jar is covered. There again we have a thin froth.

Mr. Sheridan: Side view.

Mr. Taggart: This is the side view, 41 diameters, the upper line of the froth runs across about here.

3432 Mr. Williams: Isn't that a case of very small bubbles, as the enlargement would bring it out?

A. We will be able to see on the next bubble. The bubble appears to be about the same size as in many of the previous ones.

Mr. Williams: I see a bubble there with four reflections on it.

Mr. Taggart: Yes, I have an idea that there are two bubbles there.

Mr. Phillips: 0.4 per cent pine tar oil, Butte & Superior ore.

Mr. Taggart: Here again we have this characteristic froth. The froth is in contact with the air particles wholly included within the whole surface froth.

Mr. Phillips: This is the 41 diameters.

Mr. Taggart: It is characteristic—you see it is characteristic of that oil that the bubbles were considerably larger than on the other oils used, do you not.

Mr. Phillips: Very much larger.

Mr. Taggart: The upper line of the froth is about here.

Here we have the 70 magnification and the bubbles are sufficiently heavily coated and sufficiently tough so that the cell matter has not rounded off in contact with the glass.

Mr. Williams: As I read that those are separate bubbles, with the dark lines between them?

Mr. Taggart: Yes, sir. We will see two, five, six, rather
3433 large and one rather small bubble complete the main point of that particular film.

Mr. Williams: I think that that particular picture shows how, when bubbles are crowded against each other, the adjacent walls flatten out to almost planes. I think that shows that very well, when they are crowded together in the froth.

Mr. Taggart: I should most certainly expect some flattening, yes, sir.

Mr. Phillips: This was 0.5 per cent pine tar oil. That same thing is shown clearly here. This is the top view, but the junction is practically straight lines. This is a characteristic of any substance closely packed.

Here is the same froth, side view, magnified 41 diameters, showing one of two clear spots here where the film has been rubbed off one side by the contact with the glass and here is the same froth magnified 170 diameters showing approximately the characteristics of the previous one.

Mr. Phillips: 0.6 per cent pine tar oil.

Mr. Taggart: There is no difference in this top view to comment on. The top of the froth in this particular view is about in there.

Mr. Sheridan: Side view?

Mr. Taggart: This is a side view magnified 41 diameters. Here again it is similar to the previous one and here is the side view magnified 170 diameters. I do not think that needs comment except for similarity.

3434 Mr. Phillips: This is one per cent pine tar oil.

Mr. Taggart: Again you note we have the characteristic bubble, too.

Mr. Sheridan: Right there, near the lower left hand corner we see a kind of small raised point and one large bubble. What is that?

Mr. Taggart: I have an idea, Mr. Sheridan, that that is a smaller bubble. I do not think there is a larger particle being held there. The small bubbles will sometimes appear on the surface of the larger ones and give that same appearance. I think, however, that up here at the upper left-hand corner, a little just to the left, there are particles included within the film. It is rather easier to tell that under the microscope, where you can see whether the particular protuberance has a small particle within or ore in air, but I think that this one is too large for a small particle.

Here is the side view magnified 41 diameters of the same film. This I think you said was one per cent?

Mr. Phillips: One per cent.

Mr. Taggart: The top of the froth being about along here and the

froth being sufficiently light, there is no need to call attention to that. Here again you see the same froth magnified 170 diameters.

Mr. Phillips: 30. One—1.5 per cent pine tar oil.

Mr. Taggart: This again is evidently similar to the previous froth. The side view magnified 15 diameters with the top of the froth coming in to about here. And here the froth is again mag-
3435 nified 170 diameters. The bubbles are heavily laden with solid material.

Mr. Phillips: Two per cent pine tar oil, Butte & Superior ore used on all of these tests, these pine tar tests.

Mr. Taggart: You will notice here this characteristic leathery appearance of the things, and here is one of the bubbles broken and with rather viscous film between as seen in the photograph; and a side view of the same froth magnified 41 diameters; the top of the froth running into about through here.

The Court: Why do the bubbles seem so much more towards the bottom than towards the top? They are not so distinct.

A. Some of these bubbles are drawn up along the sides. You know that the froth is higher on the sides than in the center and you get the contact then of that upper bubble with the one directly under it, which outlines this particular contact. The dark spaces above here represent the spaces below which the tops of the top bubbles lie, and the line here represents the point above which, and I have *drawing* my pointer at some point in through these two as representing approximately the top.

Here is the same froth magnified 170 diameters with a characteristic appearance of the preceding ones.

Mr. Phillips: We have no good night slide, but I think that is the last one.

Mr. Sheridan: I would like, if your honor please, to offer
3436 this box of lantern slides in evidence, en bloc, as defendant's exhibit 181, and I would like to do this with them if Mr. Williams will agree, and that is I would like to have them remain in our possession with a right to call for them at any time.

Mr. Williams: Yes, I think that would be more convenient for each party showing films or pictures of this kind.

The Court: The record will so show. I suppose that completes it.

The slides admitted in evidence and marked Defendant's Exhibit 181.

Whereupon an adjournment was taken until 10:00 a. m., Tuesday, May 1st, 1917.

Tuesday, May 1st, 1917—10 o'clock a. m.

The Court: In the matter of the application to file the supplemental and amended bill, which is also a bill in intervention, but of course it is not the labels on the bill which control, it is the substance of the bill; and even though they may not have placed upon the bill all the labels it ought to bear, it is no objection to its being filed.

This amendment proposes to bring in other parties in intervention;

they themselves are here, asking, in that they have a right as
3437 licensees of this patent to share in the proceeds of the action, in so far as there is a recovery for infringement at all. It seems to be and it ought to be the practice in patent suits to join the patentee and his licensees, in that it makes for singleness of action and prevents multiplicity of action.

As a matter of fact, if defendant knew that this patent right had been in fact assigned to licensees, and failed to make it known, and had allowed the patentees to secure a full recovery, they would still be liable to the licensees for what was properly theirs; the same as in the case for the assignment of a cause of action; if the debtor does not insist upon the assignee, if the suit is by the assignor, being brought in, and lets the assignor recover, the debtor is still subject to the claim of the assignee, so that it is really for the benefit of the defendant in this suit that these parties should be brought in. At the same time the court, knowing this, of its own motion would insist upon it, because certainly this court does not want to try this case or any part of it again, and it would be obliged to if these licensees were not here.

Now, the other feature of the proposed amendment enlarged upon the fact that the Hyde case had been decided, the decree and mandate. As the court stated the other day, as far as it is for the purpose of pleading res adjudicata, it is really anticipating the defense, that that too has been customary in patent suits. I notice in a Supreme Court decision a few days ago, and I failed to make the notation, though it is within the last 50 volumes, which makes
3438 it very definite to you of course—the Supreme Court casually observed that former adjudication should be either pleaded or introduced in evidence, without commenting on the practice. The patentee, no more than any one else, is bound to anticipate a defense. They could introduce it in evidence without pleading it. In this case when the former adjudication, by name at least, is against a party not party to this suit, fairness to the defendant requires that it should be pleaded, but it could ordinarily be introduced in evidence after the defense of invalidity is made, no replication being necessary. That is only the general law of practice and pleading.

Now, as to lack of diligence, the condition in respect to that is the same as it was when the defendant a few days ago asked leave to amend their defense and introduce new patents and the California publication. The court said there that the peculiar circumstances of this case would serve to render the delay, not lack of diligence, because both parties were resting quiescent in a large measure, waiting for the decision of the Hyde suit. So here, as far as there — not been diligence in bringing forward these assignees or licensees, the court does not think the objection is well taken, for, as I said before, the court would order them in; intervention may be had at any time prior to the conclusion of the suit, as long as it does not operate to the prejudice of the defendant, and it does not in this case. None of this new matter in the supplemental bill is any surprise to the

defendant, and so the amendment, or the supplemental and amended bill and bill in intervention will be allowed to be filed.

3439 Mr. Kremer: Your honor will allow us an exception?

The Court: Exception will be noted.

Mr. Kremer: And will your honor make a further order providing in what time we shall answer?

The Court: What time would you like, five days?

Mr. Kremer: Ten days; I think we will be here that long, surely.

The Court: You are to conclude your case this week, as I understand it, and you ought to answer before you conclude. I will give you until Saturday morning. There is nothing new in this, really.

Mr. Kremer: No, it is merely the preparation of the answer, the mechanical part of it. The answer will be in form the same as the one now.

The Court: Saturday morning.

BEN H. DOSENBACH resumed the stand for further

Cross-examination:

X Q. 422. To complete the record of November 1, 1913, what oils were used on that day?

The Court: Now you are inquiring with respect to what? Your question relates to a former one, but that former has passed out of the court's mind.

Mr. Williams: I was inquiring about the operations of the

3440 plant on November 1, 1913, that being the earliest day of which he had any record with him and I am completing that record now.

A. The oil used on November 1, 1913, was 1.29 pounds pine oil per ton.

X Q. 423. Was heat used on that day?

A. Heat was used on that day.

X Q. 424. Was sulphuric acid used on that day?

A. Sulphuric acid was used on that day.

X Q. 425. I don't think I obtained from you the tonnage of the feed to the flotation plant on that day?

A. The tonnage was 1181 tons to the mill on that day; and until such time as I can segregate that part of the concentrate which was made in the concentrator from that which was made in the flotation plant, I cannot determine exactly what the feed to the flotation plant would be on that date. This is the total amount of zinc concentrate for this day and it does not show the tonnage of lead; that is plus the mill feed, independent of the flotation plant.

X Q. 426. What would be your method of calculation?

A. My method of calculation would be the tonnage of the lead concentrate plus the tonnage of the zinc concentrate produced in the wet concentration portion of the mill subtracted from the mill heads or tonnage to the mill; that would give the total amount of ore to the flotation plant.

X Q. 427. That is to say all the material except the concentrate taken out by wet concentration goes into the flotation mill?

3441 A. That is so.

X Q. 428. And is this method of calculation the method that has been used throughout?

A. It is.

X Q. 429. There has been no different measurement taken of the dry feed to the flotation plant?

A. We have no definite method other than the calculation method, by deducting the products that are taken out before the feed comes to the flotation plant.

X Q. 430. Now, have you the record for September 13th?

A. September 13th—as to what, Mr. Williams?

X Q. 431. Have you here the monthly summary and averages for September, 1913?

A. Yes, I have the tons milled and I have the power and the oil and acid and I can give the assays for September, 1913.

X Q. 432. Individual assays for the different days' runs?

A. Some I haven't got them segregated it has been impossible for me to get all the material together from that. Any particular day that you might want I can give those days and give you all the information on those days. There is quite a voluminous record to go through.

X Q. 433. Well, I would like to have a daily itemized statement for some time in September?

A. 1913?

X Q. 434. 1913, which would approximately give the day

3442 on which the concentrates were made that were found on a car in Oklahoma on September 18th, 1913, making allowance for the usual delay in transportation?

A. I don't know how I can get that.

X Q. 435. Somewhere about that time. I presume that you didn't make any great changes then and you can take some day which in your judgment would be about the time that these concentrates were made, and let me have that day and the days thereabouts. You have got that record, but you haven't it here with you?

A. No. Maybe anywhere from one to three months or nine months before that; maybe less and maybe more.

X Q. 436. Bring the daily record of that time and we will probably be able to get something that will be of assistance. Tell me, however, what oils you were using in September, 1913?

A. We were using pine oil and some oleic acid.

X Q. 437. Pine oil and what?

A. Some oleic acid.

X Q. 438. And what general proportions of pine oil to oleic acid?

A. Approximately I should say fifty of each.

X Q. 439. And the total oil was how much to the ton or what percentage of the feed?

A. In September, 1913?

X Q. 440. In September, 1913?

A. In September, 1913, the oil used was 2.799 pounds per ton based upon a ton of mill heads.

X Q. 441. Mill heads to the flotation plant?

3443 A. Mill heads, that would be the heads to the mill, of new ore. That would make it slightly above that per pounds per ton of flotation feed.

X Q. 442. When did you commence using pine oil?

A. We started to use pine oil about June, 1913?

X Q. 443. And what was the oil proportions and the mixture at that time?

A. The amount of oil used — July was 4.24 pounds, so it would be approximately four pounds.

X Q. 444. The average oil used during July was 4.24 pounds per ton of what?

A. Per ton of ore to the mill.

Mr. Williams:

X Q. 445. In what manner was that oil proportioned; was it oleic acid or pine oil or pine oil alone, or what proportion?

A. There were some days when pine oil was used alone, and some days when it was used with oleic acid, but I should say the proportion at that time, was about 50% of each.

X Q. 446. I asked you for June.

A. There was only a day's run made with pine oil in June, consequently I gave you July.

X Q. 447. How long did you continue to use a mixture of pine oil and oleic acid in the proportion of about 50% of each?

A. Well, the proportion varied from fifty to forty and sixty. We continued the use of pine oil and oleic acid for some time.

X Q. 448. Until when?

A. Until the latter part of 1914.

3444 X Q. 449. Then what oil did you use?

A. Then we used pine oil alone. We were, at this date here, using oleic acid together with pine oil in August.

X Q. 450. When you used pine oil alone, in what proportion or amount did you use it?

A. Approximately after that it was 1.64 lbs. per ton.

X Q. 451. What day's record have you given me?

A. That is December 30th, 1914, the average to date for that month. That gives you a fair average.

X Q. 452. How long did you continue to use pine oil alone?

A. We continued to use pine oil alone, and being the principal oil that we used until December, 1916.

X Q. 453. December first?

A. No, December 22nd, it being understood that the pine oil was the principal oil that we used. However, we had occasional carload of other oils that we tried out, such as Barrett oil and pine tar oils and oils of that sort, but the principal oil that we used was pine oil.

X Q. 454. Well, take the record of November, 1916, and give me the oils or the mixtures that you used during that month. The

record that you now show me is for November, 1916, and that does not give you the information you want.

A. It does not, but the one previous to that, October 31st, 1916, will give you the average amount of oil for that month of October.

3445 X Q. 455. Give me that figure.

A. 1.50 lbs. of pine oil.

X Q. 456. Any other oils used during the month of October, 1916?

A. No other oils used.

X Q. 457. Now, give me the record of October 31st, 1916.

A. The ore milled was 2,122 tons. The mill zinc concentrate obtained was 75 tons. The lead concentrate 20 tons.

X Q. 458. That was water concentration?

A. By water concentration. The flotation concentrate that was obtained was 526 tons.

X Q. 459. And the tailings?

A. The average assay of the tailings was 1.19.

X Q. 460. The tonnage of the tailings?

A. Well, I will figure it for you.

X Q. 461. That is not given on the sheet?

A. We do not keep the tonnage of the tailings, no. The tonnage of the tailings was 1,501 tons.

X Q. 462. How did you compute it?

A. By subtracting the products that were obtained in the mill from the ore that was milled.

X Q. 463. Now, give the assay of the concentrates from the flotation plant.

A. The assay of the concentrate of the flotation plant was, for the first shift, 55.2% of zinc; of the second shift, 55.3, and for the third shift, 55.6.

X Q. 464. Now, what was the assay of the zinc concentrate from the water concentration part of the plant?

3446 A. For the first shift, 46.7; for the second, 48.4 and for the third, 47.9.

X Q. 465. On that date did you use sulphuric acid?

A. On that day sulphuric acid was used.

X Q. 466. In what amount?

A. I haven't it for the particular day, but I have it, the same as I have the oil, for the average for the month, to and including that day, which is 5.059.

X Q. 467. Did you use heat on that day?

A. A very little heat was used; however, the temperature, as I remember it in 1916, we were operating at about 35° C.

X Q. 468. And you used steam in order to get it up to that temperature?

A. Oh, yes.

X Q. 469. Did you use any other reagents on that day besides those you have given?

A. On that day we used copper sulphate solution.

X Q. 470. How much?

A. That was equal to one-tenth of a pound of metallic copper per ton.

X Q. 471. Per ton of what?

A. Per ton of ore milled, the same as the oil and acid was based upon.

X Q. 472. When did you commence to use copper sulphate?

A. It was about July, 1915.

X Q. 473. And did you continue to use it from then on?

A. We did.

3447 X Q. 474. When you started in July, 1915, how much copper sulphate did you use?

A. We used about .25 of a pound of metallic copper per ton of ore milled.

X Q. 475. And when was that increased, or was it increased?

A. It was decreased.

X Q. 476. And when was it decreased? And to what amount?

A. Gradually decreased until about the latter part of 1915, when it was found that the results were as good with one-tenth of a pound metallic copper per ton of ore.

X Q. 477. And that is the figure—this figure that you give is not the figure representing the copper sulphate, but the figure which represents the amount of copper in the copper sulphate, is that right?

A. Exactly so, yes.

X Q. 478. And that one-tenth of a pound of metallic copper per ton of copper sulphate, how long was that continued?

A. Well, that has continued up to the present time. Right now it is about .08, or a little less.

X Q. 479. Any other reagents used besides what you have testified of?

A. None, other than as a settling agent, sodium chloride; we used salt.

X Q. 480. Where?

A. For the slimes.

X Q. 481. For the settlement of the slimes in thickening?

3448 A. In thickening.

X Q. 482. And of course that salt goes into solution in the water?

A. It does.

X Q. 483. And flows through the flotation plant?

A. It does.

X Q. 484. Could you give me an idea of how much sodium chloride is present in the flotation plant as the result of that?

A. I could not.

X Q. 485. What is the general measure of its use?

A. We measure it on the amount of ore that is milled, and that figure is about .87 of a pound for the month of October, 1916, per ton of ore milled.

X Q. 486. .87 of a pound of sodium chloride?

A. Yes.

X Q. 487. Do you continue to use sodium chloride or common salt for the settlement of slimes at the present time?

A. We do.

X Q. 488. And in the same amount?

A. Substantially so, yes.

X Q. 489. This copper sulphate solution that you used, from where did you obtain it?

A. The Anaconda Mining Company.

X Q. 490. Have you any analysis of it?

A. Contains about 1.35, approximately, of metallic copper; contains some salt and some acid.

X Q. 491. Does it contain any copper chloride?

A. I have not made determinations for copper chloride on that.

3449 X Q. 492. Do you happen to know what kind of a product it is?

A. It is the Leach solution which is obtained from the leaching plant of the Anaconda Company.

X Q. 493. The solution that has done its work in the leaching?

A. No, the solution that results from the leaching by sulphuric acid.

X Q. 494. And that is the copper sulphate that you have used in all your experiments here?

A. Exactly so.

X Q. 495. Well, haven't you an analysis of that material that you can give me?

A. I might have with me, I am not positive about that. I can make a search and see.

X Q. 496. Suppose you look it up and get it later so that the court won't have to wait?

A. All right.

X Q. 497. How about the water that flows through your flotation plant? What is your water system? Where does the water come from that goes through the plant?

A. Why, part of the water comes from the North Butte extension property which is situated and located about a mile from the Butte Superior plant, and part of it comes from the city of Butte and the balance is reclaimed water that is used over again from the settlement of the slimes.

X Q. 498. And from the concentrate?

A. Also from the concentrate.

3450 X Q. 499. That is to say, you economize by getting the water out of your products and sending it back again through the system? Is that right?

A. Yes, sir.

X Q. 500. Now, I want some of the proceedings after December 22nd, 1916. We will take the period from February 4 to 28th, 1917, and I note that you give the assay of the feed to the flotation plant as 13.29 per cent zinc, and the ore to the flotation plant plus circulating middling treated in flotation as 20.25 per cent zinc. How was that arrived at? By measurement or computation?

A. That was arrived at by determination, assay determination.

X Q. 501. By assay of the total feed?

A. Ore to the flotation plant plus the circulating middling treated in flotation.

X Q. 502. Now give me the figures about the circulating middlings. In the first place give me the tonnage of circulating middling?

A. I haven't the tonnage of circulating middling. The tonnage that is given here is the tonnage of ore to the flotation plant, 26,262 tons.

X Q. 503. Is that new feed?

A. That is new feed which contains 13.29 per cent zinc. The ore to the flotation plant, plus the circulating middling treated in flotation contains 20.25 per cent zinc, but I have no tonnage of that material. It is impossible to get it.

X Q. 504. Well, do you take a sample of this total feed
3451 and do you from this sample make an assay to determine the amount of copper in it?

A. As before stated, I make an assay to determine the amount of copper in it.

X Q. 505. And zinc?

A. Yes.

X Q. 506. And you do not consider the tonnage of the middlings returned?

A. No, the middlings returned go right with the original ore when it comes in; it is all elevated together to the machine.

X Q. 507. Well, then, in the absence of that tonnage can you give me the zinc content of the middlings returned?

A. No, I can't give you the zinc content of the middlings returned.

X Q. 508. Can you give me the amount of oil in the middlings returned?

A. I cannot give you the amount of oil in the middlings returned.

X Q. 509 Or the percentage?

A. Nor the percentage either.

X Q. 510. The only measurement that you have is the measurement of the amount of zinc in the middlings returned? Is that right?

A. The only measurement that I have is the amount of zinc in the feed to the flotation plant plus the circulating load; and I also have the oil determination for that material. That is the actual material that goes to the machine.

3452 X Q. 511. Can you, Mr. Dosenbach, compute the tonnage of the middlings and the amount of oil in the middlings from these figures?

A. It might be approximately computed, if you have the two determinations and one tonnage.

X Q. 512. State what your method would be?

A. Why, having the total tonnage to the flotation plant containing its relative amount of zinc, having the assay determination of the material to the flotation plant, which includes that tonnage of the original ore plus some indefinite tonnage that contains some indefinite amount of zinc, it might be possible to. I have not gone over it to see.

X Q. 513. Have you a general idea of the richness of these middlings and the amount of zinc which they contain?

A. Why, it can be seen that if the feed to the flotation plant plus the circulating middlings that is treated in the flotation plant, which is the flotation machine feed, contains more zinc than the original ore did, why it is quite possible that the middlings returned is richer than the original ore that came in, so as to bring the average of the two up to a percentage, which in this case is approximately seven per cent richer in zinc than the original ore.

X Q. 514. That is obvious. But I asked you whether you had any idea as to the richness of these middlings?

A. The middlings possibly might run on the average 25 or 30 per cent zinc.

3453 X Q. 515. Of course if they run much higher than that they would not be returned as middlings? Isn't that true?

A. Yes, that is very true.

X Q. 516. I think you made a general statement about the proportion of middlings returned to feed. Now, what definite basis have you for that statement? You said sometimes it was greater than the original feed?

A. Yes. The basis of that is that a glance at the tailings of the feed to the flotation machine itself would give you some idea that the amount of material returned is as great or greater than the amount of the original ore sent to the flotation plant.

X Q. 517. Have you the original records of the days around February 4th to 28th, 1917?

A. I have.

X Q. 518. Let me see them please?

A. I haven't them with me other than the tabulated data that gives each day's operation.

X Q. 519. I would like you to bring with you the records upon which these tabulations were prepared for the period of February 4th to 28th, 1917. When you changed from the smaller quantities of oil to the somewhat larger quantities on December 22nd, 1916, what changes did you make in your mode of operations and the machines used and so forth?

A. There were no changes made in operations other than making provision for connecting the tube mill discharge direct to the flotation pyramid machine that was put in operation on that day,

3454 and also connecting a portion of the slimes which now were the general slimes that went to the general flotation plant to that machine itself.

X Q. 520. Well, then, that machine was put in operation on that day? That was one change?

A. That was one change, naturally it would be.

X Q. 521. You started with a pyramid machine and where did you feed the oil to this pyramid machine or the feed to this pyramid machine?

A. Just before it went to the first cell. That was considered in the series of rougher cells; that was #2 cell on that pyramid.

X Q. 522. At what times during your operations did you feed the oil or any portion of it ahead of the tube mill?

A. We made frequent changes of that sort and fed the oil to the head of the tube mill at various times during the operation, but found that we did not obtain any better results with the oil going to the head of the tube mill than we did with the oil going to the feed after it left the tube mill or the tube mill proper.

X Q. 523. How long at any time did you continue to feed the oil to the head of the tube mill or ahead of the tube mill?

A. Oh, possibly we continued for a period of four to six weeks.

X Q. 524. And when was that?

A. That was after starting in December. We made experiments to see whether it would be advisable or not, and then we
3455 would disconnect it and send it to the other place.

X Q. 525. After December 22nd, 1916?

A. Yes, that is what I am speaking of.

X Q. 526. When did you last feed the oil ahead of the tube mill?

A. To the best of my recollection it was in March of this year, the latter part of March.

X Q. 527. Were you in the plant on Sunday morning, before the arrival of our representatives, Sunday last?

A. I was not, no.

X Q. 528. Prior to the use of the larger quantities of oil, that is to say prior to December 22nd, 1916, did you take any part of your concentrate as first concentrate from one of the machines without retreatment?

A. Please state that again.

X Q. 529. (Question read.)

A. Yes, we have done that.

X Q. 530. Over any considerable period of time?

A. Not for any great considerable period of time.

X Q. 531. What was the general practice?

A. The general practice was to clean and reclean but occasionally when the system was overloaded and it was necessary to relieve a part of the system, why the concentrate from the rougher machine with the rougher concentrate was sent to the bin for a period for a sufficient time to enable the plant to readjust itself.

X Q. 532. When did you commence to both clean and reclean your concentrates?

3456 A. In November, 1913.

X Q. 533. When did you commence to clean and reclean and again re-clean your concentrates as you were doing last Sunday?

A. We also did that in 1913, about the time, after November, 1913; our first cleaner was arranged so that we could make two cleaners out of it.

X Q. 534. And then in addition to that there was a re-cleaner?

A. A re-cleaner; there was a third cleaner.

X Q. 535. Can you give me any other comparative figures of the return of middlings to original feed before December 22nd, 1916, and after December 22nd, 1916?

A. I should say that they were approximately the same, or very nearly so.

X Q. 536. When did you install the Callow machines?

A. They were installed in the latter part of 1915.

X Q. 537. And for what purpose have they been used since their installation?

A. They have been used merely to take care of the fluctuations that occurred in the Janney machines that are placed in the system ahead of them—take the feed before they take the feed; for instance, if a Janney machine is down, or any part of it is down for any reason whatsoever, it sort of leaves the pneumatic machines below to take care of the feed as it goes to it.

X Q. 538. What do you mean by taking care of the feed; do you use them for producing finished concentrates?

3457 A. We do not; we produce middlings from these machines only, and they are merely there as a safety valve, you might say.

X Q. 539. Their function is to clean the tailings?

A. To assist in cleaning the tailings, yes, and as a safety valve to take care of any fluctuations in the upper part of the plant, should it suddenly go down, or any part of it go down.

X Q. 540. Before December 22nd, 1916, did you take into account the oil in the circulating middlings?

A. We did not.

X Q. 541. Since December 22nd, 1916, you have made frequent changes, have you not, in the flow sheets as to the flow of the material to the different machines?

A. Since December 22nd, 1916, yes. The plant was changed over from the straight series type of machines to the pyramid type of machines and that necessitated the changing of the flow sheets.

X Q. 542. And then, as I understand it, the flow sheet as exhibited to us last Sunday was different from the flow sheet as you explained it to us on Saturday, is that right?

A. Well, I did not have time to conclude it Saturday; I was endeavoring to explain the cleaning arrangements, which I showed on that flow sheet to the two cleaning arrangements, and I endeavored to show this, consequently I did not draw any line for these machines except No. 7 pyramid, to give you the actual flow through the pyramids as original material.

3458 X Q. 543. When did you commence to use one of the pyramid machines as a cleaning machine or recleaner?

A. In February, I think it was, when we started to use it; February, 1917. Then it was discontinued again, and then it was used again.

X Q. 544. I notice that in Exhibit 158 in the period January 30th to February 3d, 1917, the estimated recovery is given as 99.20. I note also that in the daily proceedings sheet, Exhibit 159 for January, there is an item which you explained, on January 31st, 130.70% recovery estimated. Is that figure of the calculation the one which

accounts for that very high 99.20 in the estimated recoveries from January 30th to February 3d?

A. I should say that it was.

X Q. 545. So that that particular figure, 99.20, as a representative of the recoveries on the operations of this particular test, may be treated as having been greatly exaggerated by the ordinary methods of computation and balancing up at the end of the month, is that right?

A. At the end of the month, yes, sir.

X Q. 546. You did not furnish any table of the daily operations from December 22nd to January 1st, did you?

A. No, because there was just a portion of the plant in operation with the larger quantities of oil at that time, and the pyramid machines, as shown in one of the reports, gives the results of that particular operation; that is, the tailings from the pyramids
3459 after the assays had been made which are reported on that sheet, joined with the other tailings and was taken as a general sample for our rgular mill record.

X Q. 547. That is to say, it was a period of experimentation, and the operations in the larger amount of oil were practically those that appear in the table, Exhibit 163, is that right?

A. I should say that it was a period of more or less oil used in the plant for the various machines, due to the fact that we did not have the oil to operate the entire plant, so we operated on what machines we had the oil for.

X Q. 548. Why don't you say that it was because you were experimenting and did not know exactly how to handle the larger quantities of oil; that is the truth, isn't it?

A. It is not.

Mr. Scott: Mr. Williams, I would ask you what you mean by large quantities of oil, whether you mean one thing or another.

Mr. Williams: I think that the reports which the witness has produced of the test that I refer to are sufficient for the edification of the witness.

Mr. Scott: Will you kindly state what you mean by large quantities of oil?

Mr. Williams: Do you object to the question which I asked?

Mr. Scott: I object to it because it is too indefinite—large quantities of oil. I refer to the last question.

3460 The Court: The witness apparently understood and answered. I think the objection comes too late.

Defendant excepted.

X Q. 549. In the following report that you have given of the daily operations, I don't find the application of the oil of the 68 different varieties of oil mixture that are described. The 53 varieties of the regular operations, shown in Exhibit 160, do not appear in the daily reports, the last one being variety No. 50, on March 31st, 1917.

A. That is 50.

X Q. 550. There is an interregnum, is there not, in the operations

of April, wherein the other three of the 53 varieties were used, as to which you have furnished no information?

A. Well, as I said yesterday, we keep our oil in numbers, and it is the only way to keep general track of the oil mixture when we are using more than one oil; consequently these three oils must have been used on one of the days in April.

X Q. 551. You have given a general summary of April 1st, 1915. Will you give a record of the daily operations?

A. I can supply a record of the daily operations, but I think it would take the afternoon. I have been so busy in April here that I have not had a chance to do that.

X Q. 552. Please do that so as to complete the record, and make the daily records correspond at least for the latter part of the
3461 work, with your general flotation operation sheets.

A. All right.

X Q. 553. Now, I don't find in these 53 varieties of regular operations, and these 16 varieties of experimental operations or operations in the pyramid machines—the exact oil mixture that has been testified of here. When was that mixture adopted?

A. Well, as I told you, that is the mixture that we endeavor to run, and in a number of instances there, while the actual figures may not show it exactly, those are the actual proportions taken by weight and the figures 70, 18 and 12 is the oil mixture used. After 24 hours of operation, the oil mixture may come out 70, 16 and 14, showing the actual weights that had been used. That is necessary to keep track of our oils.

X Q. 554. Variety No. 28 is 10% kerosene, 70% Jones' crude and 20% of pine, which seems to me to be the nearest approximation to what you have given.

A. That is fair all right, I should say.

X Q. 555. Where do you get this kerosene?

A. Well, that is purchased from the Utah Oil Refining Company and from the Continental Oil Company and from the Texas Oil Company.

X Q. 556. Is the kerosene such as is sold on the market for illuminating purposes?

A. As commercial kerosene, yes.

X Q. 557. Isn't it a cruder and cheaper grade?

A. We have had one or two cars of a cruder, cheaper grade.

3462 X Q. 558. What is the Jones crude oil, and where do you get it?

A. That is an oil that comes from Kansas; it is called Jones' crude, but I think it is more of a residuum than it is a crude oil.

X Q. 559. Of petroleum?

A. Of petroleum, yes, sir.

X Q. 560. The No. 1 creosote, what is that?

A. That is a hardwood creosote, a fractional distillate from the hardwood.

X Q. 561. Where do you get that from?

A. That comes from Marquette, Michigan.

X Q. 562. No. 2 creosote?

A. That is also another fraction of a hardwood distillate, it is a hardwood distillate, and is somewhat similar to the #1.

X Q. 563. Do you know what the difference is between the two?

A. Well, it is a difference in the fractionating of the two.

X Q. 564. Now what is this fuel oil?

A. The fuel oil is a paraffin residuum.

X Q. 565. Is this known as Jones fuel?

A. It is not. That is known as Graybull fuel.

X Q. 566. Where do you get it from?

A. From Graybull, Wyoming.

X Q. 567. Now, the pine oil, where do you get that from?

A. Principally from the Yaryan Resin and Turpentine
3463 Company.

X Q. 568. Do you have any pine oil which is not Yaryan pine?

A. Right now we haven't, no.

X Q. 569. But you have had?

A. We have had other pine oils that we have tried out. Everything in that report is Yaryan pine oil.

X Q. 570. No. 4 Barrett, that is a wood tar, is it?

A. That is a coal tar distillate.

X Q. 571. And where do you get that from?

A. From the Barrett Manufacturing Company.

X Q. 572. What was this oil called tar?

A. That is crude coal tar.

X Q. 573. And where do you get that from?

A. From the Butte Gas Works.

X Q. 574. What is this paraffin base?

A. That is a crude paraffin oil of paraffin base.

X Q. 575. Can you complete the supply of specimens of these oils that are tabulated by you? I believe we have one or two, but not by any means all.

A. I can.

X Q. 576. Will you do so as promptly as possible?

A. I will if you will let me know what quantity you want.

X Q. 577. Kindly talk to Mr. Chapman or Mr. Higgins and give them what they want. Will you do so?

A. Yes, if they don't want too much.

X Q. 578. Now, during the period before December 22nd, 1916, did you make any determination as to the circulating middlings, any assays or measurements?

3464 A. No. We have at times endeavored to get some experimental data of these middlings, but the volume of material that we were returning was quite great and it was very hard to get an accurate tonnage sample, and an assay of that material so I have actually taken these samples and thrown them out, for I did not think they would be accurate enough to submit.

X Q. 579. Then you haven't any reliable record of these middlings prior to December 22nd, 1916? Is that correct?

A. I have no reliable records on the middlings prior to or after December 22nd, as to the amount and the assay.

X Q. 580. Do I understand that after December 22nd and during the period up to the present time you have had no reliable record of the middlings?

A. As to what?

X Q. 581. As to any part of them?

A. No.

X Q. 582. What did you mean when you said that you had no reliable record before or after December 22nd?

A. I meant that we didn't have any.

X Q. 583. Well, now the figures that you have given in these daily returns, do you include those as unreliable?

A. Absolutely not. This is the middlings plus the ore and not the middlings alone.

X Q. 584. Well, prior to December 22nd have you any figures that will show the middlings plus the ore feed?

3465 A. I have.

X Q. 585. Give me a record of some time shortly before December 22nd, 1916?

A. I will have to supply them for you, Mr. Williams. I can supply all of December and November of 1916 for you if you so desire.

X Q. 586. You commenced to make up that record in December, 1916?

A. No, we made it previous to that time, as to the assay of the flotation machine headings or the ore plus the circulating middling treated in flotation, and I can supply that for an average period or any time that you might wish.

X Q. 587. Well, supply it for November and December, 1916, and then for December, 1915?

A. All right, sir.

X Q. 588. Now, are we to have another flow sheet which will give the actual operations as they were exhibited to us on Sunday last?

A. I will supply you with another flow sheet of the actual operations as they existed on Sunday last.

X Q. 589. Your Janney machines are operated with what speed of impellers?

A. About 570 revolutions per minute.

X Q. 590. And can you give me the peripheral speed?

A. I can figure it for you.

X Q. 591. Give me the diameters?

A. 20 inches for the upper impeller and 15 inches for the lower impeller.

3466 X Q. 592. And is that maintained throughout the plant, that speed?

A. That is.

X Q. 593. Have you used an oil known as Jones fuel oil?

A. We have used an oil known as the Jones crude oil.

X Q. 594. Have you used an oil known as the Jones fuel oil?

A. No.

X Q. 595. You haven't used any different varieties of Yaryan pine oil?

A. Yes.

X Q. 596. Can you describe these different varieties?

A. I can.

X Q. 597. Please do so?

A. One variety we have used was a pine oil that was comparatively pure, while other varieties that we have used were not so pure, containing more of the solvent material, such as the paraffin solvents that are used in the extraction of the pine oil from the wood. These pine oils having a lower specific gravity than the ones which were comparatively pure, which had a specific gravity of about 0.93.

X Q. 598. Can you give a trade description of these different varieties?

A. The pure pine oil is the Yaryan standard pine.

X Q. 599. And the other?

A. The others are #2 Yaryan pine.

3467 X Q. 600. That gives two varieties. Are there any others?

A. There are others that range between the #2 and the standard Yaryan, which numbers I don't remember offhand.

X Q. 601. But they have certain commercial numbers, have they?

A. I understand that they have. Some we have obtained samples of.

X Q. 602. What are you using now?

A. We are using a mixture of the standard and the #2.

X Q. 603. How long have you used them, about?

A. We have used them for the past several months, as we have not the tank capacity to keep them separated; we have to mix them.

X Q. 604. Since December 22nd, 1916, what varieties of Yaryan pine oils have you used?

A. The standard and the #2.

X Q. 605. And they have generally been mixed?

A. They have generally been mixed and in some instances have not, depending upon our tank capacity. We had room in one tank to put the lone oil.

X Q. 606. Can you give me any figures giving the assay of the middlings or whatever you call it that is overflowed from the pneumatic or Callow plant?

A. A fair average would be between five and 12 per cent zinc.

X Q. 607. And that is based upon your assays from time to time? Is that right?

3468 A. Yes. We don't assay them regularly, but we take occasionally a sample of it to determine its value.

X Q. 608. Can you give me an idea of its tonnage?

A. That would be pretty hard. I have made no determinations on that particular matter.

Mr. Williams: For the present and in view of the fact that there are so many other things that the witness has to supply I suspend the cross-examination.

Redirect examination.

By Mr. Scott:

R. Q. 609. You were asked on cross-examination something about when your attention was first called to using large amounts of oil, and you stated that—referred to some circumstances at the Utah Copper Company, I think, in the summer of 1913?

A. I did.

R. Q. 610. Will you explain that circumstance? What happened?

A. It was in the summer of 1913 when I went to Garfield, Utah, to the Utah Copper Company to assist in some flotation work for a period of two or three months. While there we determined the best methods that we knew of to float the ore or rather the low grade concentrate, and it was found that by only using coal tar or its derivatives, or a mixture of coal tar with the crude oils that good results were obtained when using a large quantity of the oil; and it was impossible to get the results at that time with a smaller quan-
3469 tity. By "large quantity" I mean we had used as high as thirty and forty pounds of oil per ton, at that basis, in the small apparatus, and the results were very much poorer with quantities that were smaller than that, say ten pounds or five pounds; and with a smaller quantity one or two pounds, we couldn't get anything. And at that time it was upon this investigation that we determined the relative importance of large quantities of oil.

R. Q. 611. Can you state about how much insoluble the Butte & Superior ore carries, mill run?

A. On an average I should say between 65 and 70 per cent. A fair average would be 67 per cent insoluble.

R. Q. 612. What would be the figure for the flotation feed?

A. Well, the flotation feed would be somewhat higher than that, possibly 72 per cent.

R. Q. 613. On account of what?

A. Having some mineral taken out of the original ore.

R. Q. 614. When you began to use upwards of one per cent of oil was the time of agitation, or the degree of agitation, time of agitation, changed in the Butte & Superior plant?

A. It was not.

R. Q. 615. Did you ever use copper in a different form from that you referred to as being purchased from the Anaconda Company?

A. Yes.

3470 R. Q. 616. In what form?

A. We have used copper sulphate, a solution produced from the copper sulphate crystals.

R. Q. 617. Ordinary commercial crystals?

A. Yes, ordinary commercial crystals.

Recross-examination.

By Mr. Williams:

R. X Q. 618. When did you use copper sulphate produced from crystals?

A. We used that when we first started the operation in 1915 with copper sulphate. The first copper sulphate that we used was made from crystals, made into a solution.

R. X Q. 619. And about how long did you use that kind of copper sulphate?

A. Well, I don't remember exactly when we started using the A. C. M. solution, the Anaconda Copper Mining Company solution; but I do know this: at various times it has been difficult to get the Anaconda Mining Company's leach solution, and it is necessary for us to use the copper sulphate solution. We keep a stock of it on hand at all times and can change to the copper sulphate crystal solution, which gives equally as good results as the Anaconda Mining Company's leach solution.

R. X Q. 620. Well, you can give me a general idea as to when you commenced using the Anaconda Mining Company leach solution, can you not? Please do so.

3471 A. About a year ago, I think, approximately.

Mr. Scott:

R. X Q. 621. Have you drawings of these machines you have used in your experiments, or some of them?

A. Yes, I have.

R. X Q. 622. Have you them with you?

A. I have. I have a drawing here of the cataract machine that I used in producing the Everson procedure.

Mr. Scott: We will put this in evidence if there is no objection, so they will be convenient in the record to refer to the different types of machines.

Mr. Williams: No objection even to the violation of the fundamental principles of perspective that appears in the drawings.

Mr. Scott: I offer the drawing of the cataract machine in evidence, this being the machine used by Mr. Dosenbach in one of his Everson experiments.

The Court: What machine was that?

Mr. Williams: Out of the German publication. It is the oil purifying machine. Of course I have a general objection to the use of that machine.

The Court: It will be admitted.

Drawing admitted in evidence and marked Defendant's Exhibit 182.

Mr. Scott:

R. X Q. 623. Have you drawings of any of the other apparatus?

A. Here is the Janney machine.

Mr. Scott: We offer in evidence a drawing showing the
3472 Janney circulating machine in section, this being a drawing of the machine used by Mr. Dosenbach in one of his experiments.

Mr. Williams: I suggest that that be corrected to properly represent the machine that is in evidence. The correction is not a large one and can easily be made, showing the dome top. With that correction I have no objection.

The Court: Well, the correction will be made.

Drawing admitted in evidence and marked Defendant's Exhibit 183.

Mr. Scott: I offer in evidence, drawing of the square glass jar machine used by Mr. Dosenbach in his experiments.

Drawing admitted marked Defendant's Exhibit No. 184.

Mr. Williams:

R. X Q. 624. In regard to defendant's exhibit No. 182, representing the so-called cataract machine, I observed at your plant an oil mixing machine provided with a revolving impeller and baffles, or at least one baffle. You have that construction in mind, have you not? The oil mixing machine at your plant which was mixing the oil that you were using on Sunday last?

A. Yes.

R. X Q. 625. That machine has a revolving impeller about the same as in this cataract machine, has it not?

A. It has a revolving impeller.

3473 R. X Q. 626. About the same as this cataract machine?

A. No; it has a very narrow blade.

R. X Q. 627. It has a baffle, has it not?

A. Yes, it has a baffle.

R. X Q. 628. At what speed is it rotating in your plant, mixing the oil?

A. It is rotated at about twelve to fourteen—I should say offhand—revolutions per minute. I wish to say, however, that the oil is placed in that oil mixing tank up there, and it is not necessary to revolve the impeller any faster than it is going for the purpose that we desire.

Mr. Scott: I offer in evidence the Janney circulating machine which Mr. Dosenbach used in his experiment.

Mr. Williams: The machine, while of interest, is irrelevant as to any of the issues in this case, because the record shows that it is a machine that was invented about 1913 or 1914, and is therefore, and can not therefore, be any part of the prior art. I should like a ruling upon that, if your honor please.

The Court: Well, the court will allow it to be admitted. The objection is overruled.

Plaintiff excepted.

The Court: Experiment has been made with it before the court, and to repeat them, perhaps the machine ought to be here. The exception will be noted.

Machine marked Defendant's Exhibit 185.

3474 Mr. Scott: I offer in evidence the machine used by Mr. Dosenbach in his experiments and referred to as the cataract machine, the same following the German publication referred to by Dr. Sadtler.

Mr. Williams: The same general objection; it is no part of the prior art.

The Court: For the same reasons the court will overrule the objection, and exception will be noted.

Machine admitted in evidence and marked Defendant's Exhibit No. 186.

Mr. Scott: I offer in evidence the machine used by Mr. Dosenbach and referred to as the Fryer Hill machine.

Mr. Williams: The objection to the introduction of that machine of course repeats the objection that was made to the experiment in it. That machine is a figment of the imagination of counsel, and has no part in the record or in the proceedings in court, and I object to it on the ground that it is incompetent, irrelevant and immaterial.

Mr. Kremer: I don't know whether that is a compliment or not, Mr. Williams.

Mr. Williams: It is a compliment to the ingenuity of counsel.

The Court: It is the opinion of the expert that the machine follows the publication, and experiments have been made with it, and for the same reason the court will allow the machine to be introduced
3475 in evidence and the objection will be overruled and exception allowed.

Fryer Hill machine admitted in evidence marked Defendant's Exhibit No. 187.

Mr. Scott: I offer the square glass jar machine in evidence.

Mr. Williams: The general objection as to that. The particular objection was to the speed at which it was rotated.

Objection overruled; plaintiff excepted.

Machine admitted in evidence and marked Defendant's Exhibit No. 188.

Mr. Scott: I offer in evidence the cone Gabbett apparatus, including the up-cast appliance.

Mr. Williams: As these are reproductions of the real prior art, as far as I can see, there is no objection.

Machine admitted in evidence, marked Defendant's Exhibit No. 189.

Whereupon further hearing was adjourned until 2 o'clock p. m. May 1st, 1917.

3476 2 o'clock p. m., May 1st, 1917.

Prof. WILDER D. BANCROFT recalled for further

Direct examination.

By Mr. Scott:

Q. 1. You have called my attention, Prof. Bancroft, to the fact that in your testimony the other day, appearing on page 1106 of the typewritten transcript, some of the percentages you mentioned were not stated accurately.

A. Yes. I stated that one-tenth of one per cent of oil on ore was approximately 6% on mineral when the ore contained 17% mineral, and was 25% of oil to mineral when the ore contained 4% mineral. That seems to have been a case of getting lost on the decimal point; those figures should be 0.6 and 2.5 respectively, which rather spoils the burst of eloquence that I indulged in. Of course if I had realized that the decimal point was misplaced I should have said things running from 0.1 to 1%, instead of doing it as I did.

The Court: It seems you were indulging in agitation right then.

A. It certainly looks like it.

By Mr. Scott:

Q. 2. Professor, will you please tell us when you first saw a mineral froth, one of these concentration mineral froths?

3477 A. Well, as near as I can fix it, it was either the end of March or the first few days of April of this year.

Q. 3. How did you happen to see it then?

A. Why, because Dr. Sadtler telegraphed to me in the middle of the month of March to know whether I would consider coming out here and testifying in this case, and I told him that I could not tell until I had talked the matter over with him, because, as a matter of fact, I did not know which side Dr. Sadtler was on, and after that, of course, I began to get fairly busy looking up the details, because befort that I had been simply interested in the general theory of it as a minor problem in colloid chemistry.

Q. 4. Your previous interest in it had been entirely disconnected from the concentration of ores; was that the case?

A. Oh, yes; I did not care anything about that. The thing that interested me in it has been that it is a practical application which connects in with two apparently different things; that is, we have emulsions, which are drops of one liquid—cod liver oil, for instance, suspended in another, and those drops are stabilized by adsorbed solids, and I have been doing a great deal of experimental work, or having it done, in the last few years, on the theory of emulsions. The next step is the theory of froths, because you can consider a froth as an extreme case of an emulsion, where you have got air or any gas, which may be considered as a very dilute liquid, in-

3478 stead of the liquid. One always likes to make occasional reference to the fact that these things that we have been

talking about are of interest from another point of view than the purely theoretical, because the student is much more interested in the practical side than in the other, and of course the bulk oil process does come in under this head, where you have two layers of liquid separated by the metal. But the only experiments that I have ever done was this same one that has been done here, of the copper powder and of the aluminum powder.

Q. 5. Then I take it that the lectures—I think you said one lecture a year that you had to deliver—for the past three or four years, have been devoted to this theoretical and scientific aspect of the emulsions and of froths?

A. Yes, to show the connection between emulsions and froths, and that we did have these particular things coming up as a special technical application, but of course as far as I was concerned, I never cared or really knew anything about the special detail, because it was perfectly obvious that if we had air in there the things would float better than if we did not have air, and from the scientific point of view the problem never came up as to the special requirements or the methods of doing it.

Q. 6. Certain passages have been quoted to you from your article in Metallurgical and Chemical Journal of June 1st, 1916, the quoted passage relating to the nature of mineral floats formed with different quantities of oil. Were these statements based upon your
3479 own investigation or upon information otherwise obtained?

A. Why, they were based on information otherwise obtained; that is, we had done no experiments, as is shown in the statement seven lines from the end of that article: "We have not yet made any experiments on the factors affecting ore flotation when the oil is reduced to a minimum, so I will not discuss that point at all."

Q. 7. Now, referring to the passage from this article, Metallurgical and Chemical Engineering, which was quoted in question 221, appearing at page 1144 of the typewritten transcript, have you found anything from investigations made by yourself to confirm the statements contained in the quoted passage?

A. From experiments that we have done this winter on the theory of froths, and from the experiments that I have also done since I have been out here, I satisfied myself, somewhat to my sorrow, that that is all wrong, and that it was a very unfortunate paragraph to have written.

Q 8. Will you state how you originated the series of experiments that you made when testifying the other day?

A. It was perfectly clear to me that you ought to be able to stabilize a froth with any solid which would be adsorbed on it; and, if I were considering it purely from a scientific standpoint, I would have been satisfied to let it go with the statement of the fact that you could stabilize it with zinc sulphide or lead sulphide. But my expe-
3480 rience has been that in every particular industry the people think that there is something specially mysterious about that and that the ordinary laws do not apply to it. That is, the literature is full of the statements that ore flotation is essentially mysterious and uncanny. If you take the people who make leather they will tell

you that tanning is entirely different from any other industry under the sun, and that no laws apply to them. You hear people say the same thing if you talk to the people who dye cloth, that is they consider that the dyeing of cloth is quite different from anything that anybody else has ever known anything about, all of which is of course not so. So it seemed wiser to take other substances which were not directly connected in any way with flotation, and Messrs. Taggart and Beach talked the matter over with me to decide what substances would be the best for the purpose of these tests. We decided on lycopodium powder because we knew that that was not wetted readily by water, and consequently had a distinct adsorption for air. We took white lead because I knew that linseed oil will displace water from white lead. While I did not know that the same thing would hold in these other cases, it seemed to me very probable; and the time being short we did not want to run a number of things that were likely not to work. We took lamp black because I knew that the different forms of carbon black have very strong adsorbing power and that among other things acetic acid is adsorbed by lamp black; so that these seemed to be the best things to start in
3481 with. I have no doubt we could find dozens of other things if we had time but it would take us about two days to show them.

Q. 9. Are there any other passages in the "Engineering and Metallurgical Journal" that you would like to comment on?

A. I have marked several passages in here which do not represent at all my present views. As regards to the other paragraphs they are not all worded quite the way I should do it now, but they are substantially correct. First, there are two typographical errors which I should like to correct. On page 632, in the paragraph beginning with the word "Winkleblech" the word "benzene" in there should be spelled with an "i" benzine and not with an "e." In the next paragraph the word "benzene" should also be spelled with an "i" in the first place in which it occurs. It is all right in the second. Those are small typographical errors which were not corrected because I did not see the proof. Now, as to the paragraphs which are pretty bad from the present point of view. On page 632 all the way from the paragraph on the left column beginning "A large bubble" to the end of the paragraph on the right hand column ending with "more air would give a plastic mass; with still more would give the bulk oil process." The statement in that about saponin is all wrong, and the part in there about the cause of the variation in the amount of oil is also wrong. While there are occasional sentences in there that are all right, it is safer to object to this whole thing. On page
3482 635 the paragraph beginning "If a pure liquid does not form a froth with air" should come out. It is a perfectly suitable paragraph in itself but as I now know it doesn't have anything to do with flotation. That point as a matter of fact is covered in my testimony the other day. On page 635 the sentence reading "Now that we are a little more clear as to the cause of frothing" should also come out because I wasn't so clear in regard to the question of frothing, especially not as regards the theory of frothing agents, as I am now.

With these exceptions I think the other is practically all right. Anyhow, I am willing to be responsible for it as representing substantially my views at the present time.

Mr. Scott: I will try and get you another one of these if you will give me this one to put in evidence.

A. Yes, sir.

Mr. Scott: I offer a photographic copy of the article in the "Metallurgical and Chemical Engineering" by way of explanation of the testimony. Any objection?

Mr. Williams: No, no objection.

Document admitted in evidence and marked Defendant's Exhibit 190.

Mr. Scott: You may cross examine.

Mr. Williams: No cross examination.

Witness excused.

3483 FRANK R. WICKS, recalled, testified as follows:

Direct examination.

By Mr. Scott:

Mr. Scott: Mr. Wicks will testify to one of these reports regarding which Mr. Dosenbach's employment was insufficient to cover the period.

Q. 1. I hand you the tabulated report of the Butte & Superior Copper Company, flotation operations covering the period from 1913, first quarter, down to April, 1915, and ask you if you were connected with the operations there referred to for any period of the time?

A. I was connected with the Butte & Superior operations from December, 1912, until April, 1915, which would include this period.

Q. 2. In what capacity were you connected with the company.

A. I had the title of mill superintendent.

Q. 3. And you did actually have the superintendency of the mill?

A. Yes, sir, I was in direct charge of the mill.

Q. 4. And these operations were under your charge?

A. Yes, sir.

Q. 5. And you can and do state that these figures correctly represent the operations?

A. I have studied them over and I believe that they are; yes, sir.

Q. 6. Now, Mr. Wicks, have you compiled any figures showing the details of operations in the Chino plant covering periods when
3484 the kind of oil used remained substantially the same?

A. Yes, sir, I prepared a tabulation for the month of November, 1916.

The Court: This is not a matter that he has heretofore gone over?

Mr. Scott: This is another branch of the case we are going to take up. We are going to establish the relations between the amount of oil

and other elements in the process for the purpose of showing that that is not related in any way to the weight of the ore itself.

The Court: I asked is it a matter that he has gone over before.

Mr. Scott: No, he has not touched on this; no witness has, your honor.

The Witness: These really furnish some information that Mr. Williams requested of me.

Mr. Scott: What question of Mr. Williams brought this point up?

A. Mr. Williams was looking over the statements showing the details of operation of the vanner concentrate flotation plant at the Chino Copper Company, and he called my attention to the variation in oil and that it was in direct ratio or in direct proportion to the fluctuations in the dilution of the feed. I told Mr. Williams that that matter had never been called to my attention particularly but that it would appear from the statements that there was some relationship. So I got up some figures to show the details of
3485 that so as to show whether there was any comparison or not, and when I was doing that I also prepared a statement—some statements showing the relationship between the total sulphides in the ore and the amount of oil used, which was a matter that I also mentioned to Mr. Williams at the time I was testifying about that statement.

Q. 7. Now, the figures upon this statement which you have prepared are derived principally, are they not, from the tabulated statements that you produced the other day?

A. Yes, sir, the figures are taken from that or they are computations made from those figures.

Q. 8. Has an investigation or study of these figures been made for the purpose of determining whether there is some relation between the amount of oil and the sulphide in the ore and the solution?

A. Yes, sir. I was much interested in that and I proceeded immediately to tabulate it to see what the relationship was.

Q. 9. And has this investigation put in more definite form than this statement?

A. Well, in collaboration with Professor Taggart we prepared some charts showing graphically the relationship which the figures indicate on this sheet which I have here.

Mr. Scott: You may cross-examine because Professor Taggart will explain the calculation. I offer the statement produced by the witness entitled "Chino Copper Company, Hurley plant, data compiled from statement, form 12C, showing results of operation of
3486 vanner concentrate flotation plant, month of November, 1916."

Mr. Garrison: We, of course, object to this as not having any probative force, if your honor pleases.

Q. 10. Is it not true, Mr. Wicks, that in the operation of the flotation plant the following factors are liable to variation: first, tonnage fed to the plant per unit of time, 24 hours being the period usually employed?

A. Yes, the tonnage varies considerably.

Q. 11. How about the kind and amount of oil?

A. The kind and amount of oil varies somewhat.

Q. 12. How about the degree of agitation and aeration?

A. The duration and degree of the agitation do not vary a great deal. There is a little variation from time to time, but not a great deal.

Q. 13. Kind and quantity of reagents other than oil, is there a variation in that?

A. Yes, sir.

Q. 14. Is there a variation in the temperature of the pulp?

A. Yes, the temperature of the pulp varies according to the weather conditions.

Q. 15. Is there a variation in the quantity of the feed?

A. A considerable variation.

Q. 16. Is there a variation in the quantity of sulphide in the feed?

A. Yes, a great deal.

3487 Q. 17. Is there a variation in the quantity of oil used?

A. Yes.

Q. 18. Now, in your plant, when using the minimum efficient quantity of oil, if all the conditions above mentioned remain constant except the percentage of water in the feed and the quantity of oil used, what change do you make when the percentage of water in the feed increases?

A. Well, I find from this tabulation that I have prepared that as the percentage of water increases, the amount of oil used increases.

Q. 19. In your plant when using the minimum efficient quantity of oil, if all conditions remain constant except percentage of sulphide in the feed and quantity of oil used, what change do you make when the percentage of sulphide in the feed increases?

A. When the percentage of sulphide increases more oil is required and more oil is added.

Mr. Scott: Now, the purpose of the tabulation that we offer, if your honor please, is to show by computation and graphic diagrams actually made from the records of the mill, that the observation of the fact stated by the witness is verified, and thereby to show that whereas the patent here in suit states the quantity of oil in terms of a percentage of the weight of ore, as a matter of fact there is no relationship of that kind whatever; that the quantity of oil is related to other things entirely, namely, to the sulphide content of the ore,

3488 to the dilution of the ore pulp and to other factors—as stated by one of the witnesses some time ago, to the degree of aeration as affecting the number of bubbles and the air surfaces in the pulp. It is our point that the patent in suit not only erroneously states by implication or by direct statement—I might say that there is what has since been called a critical point that the oil must be reduced to in order to produce this froth—we not only deny that allegation, but we also deny that the very terms in which it is stated have no relation to this process whatever, namely, a relation to the quantity of ore.

I renew the offer of this report.

Mr. Williams: I have no objection to this report as it appears to be an illustrative diagram prepared to illustrate a theory; but now that we have the detail of these daily operations in this argumentative form, I think that should be supplemented by the details of these operations in the form in which they are summarizeed, and not particularized, in the record of the flotation operations of the retreatment of vanner concentrates, exhibit No. 29. If, therefore, this witness will supplement this argumentative report with a regular daily report of the operations, which will really give the basis for the argument, there is no objection to having this in evidence as an argument.

Mr. Kremer: That is really a matter for cross-examination, it seems to me.

The Court: What is this but a daily report?

Mr. Kremer: So it is; the details of that daily report are subject to cross-examination.

3489 The Court: It is nothing more nor less than a gathering together of the figures which appear elsewhere scattered through the various reports presented by the witness.

Mr. Scott: Exactly.

The Court: Of course it adds nothing to the force of his testimony, but it is simply a handy and convenient way of gathering them together, I take it.

Mr. Williams: It is a selection and computation, especially arranged from that record, not to the fundamentals of mill operation, but simply the presentation of an argument; and if this is supplemented by a report giving the information in the same detail that it appears in exhibit 29, there is no objection to having it in evidence.

The Court: Isn't that already in evidence?

Mr. Kremer: It is already in.

Mr. Williams: No, not the details of it.

The Court:

Q. 20. As I understand it, this document shows—proposed exhibit No. 191 shows that on the 1st of November, 1916, you used 8.06 lbs. of oil, and on that day the pulp contained solids 46.03?

A. Yes, sir.

Q. 21. And so on?

A. Yes, sir. The first four columns, the figures are copied directly from the original record, and the remainder of the columns with the exception of the sixth one, are computations based on these figures. May I explain that further?

3490 Q. 22. Yes, you may explain.

A. The first four columns are copied directly from the original record, the pounds of oil per ton, the per cent. of solids, the ore treated per 24 hours, the assay for copper and all are copied from this original statement covering the operations of the vanner concentrate plant for the month of November.

Mr. Kremer: It is now in evidence?

Mr. Scott: No, it is not in evidence.

Mr. Kremer: Then I made a statement that, that was wrong.

A. (continued). The next column which is headed "Percent Cu_2S is derived from the preceding column.

By the Court:

Q. 23. What is Cu_2S?

A. That is copper sulphide in the form of chalcocite, and that figure, 4.51, is derived from 3.60 in the preceding column, that is, converting the metallic copper into sulphide, in the form of chalcocite, which is the form in which our copper exists.

By Mr. Scott:

Q. 24. You mean that the first figure in that column is the copper as metal?

A. Yes, sir.

Q. 25. And in the next column you combine that copper with the sulphur that occurs with it?

A. Yes.

Q. 26. And that column gives the weight of the mineral in which the copper occurs?

A. Yes. Now, the next column which is headed, "Assay Percent Iron 17.8" that is also copied directly from this statement.

3491 Now, the next column is the percent iron which exists as FeS_2, whic his iron pyrite, or a sulphide form of iron. Then the next column is the percent of computed sulphide in metallic iron. You see the 14.4 is computed from the 6.7. One column is the metallic iron and the next column is the iron pyrite, and then the last column, 18.9 that is the sum of 14.4, which is the iron sulphide, and 4.51, which is the copper sulphide.

By the Court:

Q. 27. You can furnish or have accessible to the opposing party, the daily records from which this is made up, can you?

A. Yes, sir.

Mr. Garrison: If your honor please, may I call attention to a matter that is seriously embarassing to us. We are only furnished with one copy of these papers, which Mr. Williams has to have, and all these explanations are lost to us because the experts have no copy, and it seems to me that we ought to have two copies of these papers so that our practical men might have them.

The Court: Well, I see—You can have this one that I have, because I don't know that it aids the court very much; the court follows the testimony. Both sides ought to be as agreeable as possible and accommodate both parties so they can follow the testimony.

Mr. Scott: It is unfortunate we have no more copies.

Mr. Kremer: We have no more on our side.

3492 Mr. Garrison: You had an extra one to give to Professor Beach that might have come to us.

Mr. Kremer: Professor Taggart has one from which he is going to testify presently. I myself have none.

Mr. Garrison: I think the court could make a ruling that they furnish two copies of these papers to each side.

The Court: It should be done. The court can only say what should be done in future. You had better deprive your own expert of one and let the others have it. Your own expert will have plenty of opportunity to look at it in time.

Mr. Kremer: If your honor please, I made the statement that this was in the record in tabulated form. That is not correct. Mr. Williams interrogated the witness on cross examination about this particular month, and in that way the major portion of the first four columns came into the record.

The Court: The objection will be overruled.

Plaintiff excepted.

Tabulation referred to admitted in evidence marked Defendant's Exhibit No. 191.

3493 Cross-examination.

By Mr. Williams:

X Q. 28. I note that in the first items of exhibit 191, the assay of the iron is 17.8. The percentage of iron as FeS2, or sulphide of iron, is 6.7. In what condition does the remainder of that iron, the difference between 17.8 and 6.7, exist in the material described?

A. Principally as magnetite, which is an oxide of iron.

X Q. 29. And does magnetite enter into the froth to any substantial extent?

A. Very little.

X Q. 30. You would not consider magnetite, which is the magnetic oxide of iron, as a substance of a metalliferous character, that is, having a metallic luster and responding to the condition that floats sulphides?

A. It is not a sulphide and does not respond to the treatment which ordinarily floats sulphide.

X Q. 31. You don't float much of your magnetite?

A. No, sir; we try not to, and it floats to a very, very limited extent

X Q. 32. Then, as I understand you, the last column shows what may be termed the metalliferous mineral contained in the material?

A. It is intended to be the total sulphide content of the material treated.

X Q. 33. What is there in that material besides the 18.9% sulphides; you have stated the magnetite.

A. Yes. There is a little oxidized iron, but very little, and then the remainder is gangue.

3494 X Q. 34. Any hydrated iron oxide?

A. I don't know the condition of the iron that exists in there in solution.

X Q. 35. As I remember it, when I cross-examined you, you

showed me a table of the daily operations for the month of November, did you not?

A. Yes, sir.

X Q. 36. May I look at that table for November, 1916?

A. Yes, sir; this is the one that you wanted a copy of.

X Q. 37. Will you supply a copy of that table to me?

A. Yes, sir; I will be glad to.

Mr. Williams: That is the document that I wanted to have, your honor, for the purpose of comparison.

X Q. 38. Will you supplement that by a description of the materials used under the head "Pounds Used of Reagents." That, as I understand it, is the other reagents other than those described in other parts of the column—or have you that information at hand?

A. I have not that information at hand, Mr. Williams.

X Q. 39. How long will it take you to get it?

A. Probably five or six days.

X Q. 40. Will you obtain it and let me have it.

A. Yes, sir, I will endeavor to get it for you.

X Q. 41. Now, you have made a statement that the oil increases with the increase of the sulphides. Upon what experience do you base that conclusion?

3495 A. Well, that is something that has been clear in my mind for a considerable length of time, because of my familiarity with flotation operations, and it might be particularly illustrated by the large difference in the oil consumption between the plants which are treating high grade material, such as this vanner concentrate plant which is under discussion—and the other plant which treats the low grade or vanner tailings. For instance, if we are using the Barrett No. 4 creosote oil in both plants, the oil consumption is very considerably greater in the plant which treats the vanner concentrates than it is in the plant which treats the vanner tailings.

X Q. 42. Is that the sole foundation for your belief, aside from what these tables show that you have just produced?

A. Well, it has been a matter of observation for a long time; I have believed it to be true for the greater part of my experience in flotation.

X Q. 43. You gave a great variety of variation of conditions which affected the operation of the plant. They all contribute more or less, I suppose, don't they?

A. Yes, they do all contribute to the results or lack of results that one is able to obtain from the plant.

X Q. 44. As a matter of fact the man who runs the plant does not need to bother his head with these various considerations that you are talking about?

A. You mean the operator of the machine?

X Q. 45. The operator.

A. Yes, he is expected to get results, and he has to take care of those things.

3496 X Q. 46. How do you instruct him to regulate the plant?

A. We instruct him to get results?

X Q. 47. How is he to get them?

A. By experience and by training, which is obtained from the men ahead of him, and of course by consultation with his foreman and with the metallurgical department and with myself.

X Q. 48. What is the principal thing that guides him in his judgment?

A. The assay of the tailings and the assay of the concentrates.

X Q. 49. He does not get the assay of the tailings and the concentrate at the time that he has to make the adjustment, does he?

A. He gets the assay of the tailings every two hours; they take samples every two hours of the tailings and make assays, as a guide. The assay of the concentrate is made only from shift to shift; so that he gradually learns by experience and the appearance of the froth which runs a certain grade of copper.

X Q. 50. Isn't it a fact that the appearance of the froth is the principal thing that guides him in his manipulation of the plant?

A. No, I think not.

X Q. 51. Don't you think that he gets the appearance of the froth, and then he learns from the assays what that appearance means, and then he is guided largely by the appearance of the froth?

A. Well, I think he is guided more by the assay of the tailings than any other thing.

3497 X Q. 52. And you get that information two hours after the trouble has happened?

A. No; a sample is taken every two hours, and it probably takes thirty minutes for such a matter, to get the assay after the sample is taken.

X Q. 53. What experience have you had in running the plant?

A. In running the plant itself? Considerable.

X Q. 54. And have you made these various adjustments?

A. Yes, sir, personally.

X Q. 55. And have you always waited for assays before you made the adjustments?

A. Not always.

X Q. 56. You have usually been guided by your judgment of the appearance of the froth, haven't you?

A. I am guided chiefly by the looks of the froth in the machine. The conditions are repeated to get the bulk of the mineral in certain cells of the machine. If the conditions are not right you get a large proportion of the mineral toward the lower end of the machine and consequently more of it is carried into the tailings.

X Q. 57. And that I should say was the relative froth appearance in the different boxes?

A. Well, I think it might be more properly stated as the volume of the froth rather than the appearance of it.

X Q. 58. Examining this table, exhibit 191, I find that on November 28th you used 18.41 pounds of oil and your total sulphides were 34.6. On November 27th you used 17.85 pounds of oil and your total sulphides were 44.9 Does this seem to your mind

3498 to show that the amount of oil increases with the increase of sulphides?

A. I am rather inclined to think, Mr. Williams, that that assay of iron on the 27th is wrong, but the records showed that and so that is what I put in. However, it appears to be a very erratic point. In explanation of that I might say that the concentrate for that day contained 33.5 per cent of iron which was very considerably greater than any other single day during the month.

X Q. 59. The last figure that you have given me was taken from the detailed statement which you are going to put in evidence later? Is that right?

A. Yes, sir.

X Q. 60. Did you have mill experience at the Butte & Superior Copper Company?

A. Yes, sir.

X Q. 61. Your ore there was a great deal richer, wasn't it?

A. Yes, sir.

X Q. 62. When you were there how was the ore running?

A. Well, it was varying considerable. I think it went up as high as 22 per cent zinc at times, but it was very unusual.

X Q. 63. I note that in exhibit 158, in the first quarter of 1913, the pounds per ton of oil were 4.76 and the pounds per ton of acid were 1.68 and that the apparent recoveries were 65.34 per cent. That is a very poor operation, wasn't it?

3499 A. I haven't that statement, Mr. Williams.

X Q. 64. You just verified it?

A. I know I have but I can't recall those figures.

(Question read.)

A. Yes, sir, that is very poor.

X Q. 65. And that is an operation with too much oil and too little acid, wasn't it?

A. I am inclined to think that it was not due to too much oil because the next quarter the amount of oil nearly doubled and the recovery went up twenty per cent.

X Q. 66. And the amount of acid was more than double, wasn't it?

A. Yes, sir.

X Q. 67. And then in the next quarter the amount of oil was reduced to a still lower point, 4.14; the amount of acid was increased to 7.05 and the recovery went up to 86.49. There you were increasing the acid, reducing the oil and increasing the recovery? Isn't that right?

A. Yes, sir.

X Q. 68. And then the fourth quarter the oil was slightly increased, 4.78, the acid was still more increased 8.45, and the recovery went down to 84.97, although not very much. There we find a slight increase of oil, an increase somewhat greater in acid, and a slight falling off on the recovery. Doesn't that indicate that you were getting in these two quarters, nearer to good conditions by diminishing the oil and increasing the acid?

3500 A. Yes, it would appear that way from this statement. I think, however, that at least a portion of the improved results were due to improving mechanical conditions.

X Q. 69. Now, how long did you stay with the Butte & Superior?
A. Until April, 1915.
X Q. 70. And it was during the year 1915 that the oil was brought down to 1.49 pounds per ton; the acid maintained practically at 7.81 pounds per ton and the apparent recovery was up to 90.18 per cent per ton. That was a very great improvement, wasn't it?
A. Yes, sir, it was a very considerable improvement.
X Q. 71. And that result was obtained with an ore vastly richer in metalliferous mineral contents than any of the ores that you referred to in this table, exhibit 191, was it not?
A. Yes, but an entirely different ore.
X Q. 72. I won't ask you about metalliferous content of that ore because Mr. Dosenbach will furnish it. I suppose you haven't anything at hand that will give it?
A. No, I haven't that figure. I can say, however, that our records that were kept at that time, while I was there, were correct within the best of my knowledge.

Witness excused.

3501 EDWARD W. ENGLEMAN, recalled for further direct examination, testified as follows:

Direct examination.

By Mr. Scott:

Q. 1. Mr. Engleman, is it not true that in the operation of your flotation plant the following factors are liable to variation: first, the tonnage fed to the plant per unit of time, 24 hours being the usual unit employed?
A. It is.
Q. 2. Is the kind of oil used subject to variation?
A. Very slight variation.
Q. 3. At your plant?
A. Yes, sir.
Q. 4. And the duration and degree of agitation and aeration?
A. Fairly constant.
Q. 5. How about the kind and quantity of reagents, other than oil?
A. We don't use any.
Q. 6. You don't use any at all?
A. No.
Q. 7. How about the temperature of the pulp?
A. Does not change.
Q. 8. The percentage of moisture in the feed?
A. Varies slightly.
Q. 9. The percentage of sulphide in the feed?
A. Varies slightly.
Q. 10. The quantity of oil used?
3502 A. Varies slightly.
Q. 11. Now, in your plant when using the minimum efficient quantity of oil, if all conditions above that I have just men-

tioned remain constant except the percentage of water in the feed and the quantity of oil used, what change do you make when the percentage of water in the feed increases?

A. Increase the oil.

Q. 12. Now, in your plant when using the minimum efficient quantity of oil if all conditions remain constant except the percentage of sulphide in the feed and the quantity of oil used, what change do you make when the percentage of sulphide in the feed increases?

A. Increase our oil.

Q. 13. I think you have compiled some tabulations from your records, haven't you, showing the relation between percentage of sulphide and oil, quantity and per cent of water and oil quantity?

A. I have.

Q. 14. Are these compiled from the original records?

A. They are.

Q. 15. And to your knowledge they are correct statements of the matters set forth?

A. They are.

Q. 16. Do they cover the two departments of your mill, the vanner concentrate and the slimes plant both?

A. Yes, I have tabulations here for the entire year of 1916 on our retreating plant feed and the same period on our slimes vanner tailing feed.

3503 Q. 17. And if requested to you can supplement these tables by additional information from the records you have with you?

A. Yes, sir.

Mr. Scott: I offer this tabulation in evidence, one entitled "Ray Consolidated Copper Company, Hayden plant, data compiled from monthly statements form number 62R, showing results of operation of vanner concentrate retreatment plant during the year 1916."

Tabulation admitted in evidence and marked Defendant's Exhibit 192.

Mr. Scott: And the second tabulation entitled "Ray Consolidated Copper Company, Hayden plant, data compiled from monthly statements, form 62R, showing results of flotation operation for ten-day periods during the year 1916." "Slimes vanner tailing plant."

Tabulation admitted in evidence and marked Defendant's Exhibit 193.

3504 Cross-examination.

By Mr. Williams:

X Q. 18. Taking up exhibit 192, what does the last column show?

A. Per cent total copper and iron in feed.

X Q. 19. And those are the only two minerals that are represented in the metalliferous mineral?

A. Practically so.

X Q. 20. To any substantial extent?

A. Yes, sir.

X Q. 21. So that instead of showing the sulphide you merely show the minerals that are represented in the sulphide; in this table?

A. Yes, sir.

X Q. 22. Why didn't you show the sulphides?

A. Because I have these assays for every day of the operation during that year and they are reported as copper and iron and not as iron sulphide.

X Q. 23. Now, this last column is the sum of the two columns before it? Is that right?

A. Yes, sir.

X Q. 24. Now, those pounds of oil per ton, how do you figure that?

A. Pounds of new oil added per ton of feed treated.

X Q. 25. And this first column represents—is that "dates"—can't be dates of course?

A. This statement is made up of ten-day periods and period No. 1 is therefore the first ten days and period No. 2 represents the second ten days.

3505 X Q. 26. Where does this start?

A. January 1st, 1916.

X Q. 27. And does it run consecutively?

A. Yes, sir.

X Q. 28. And this last period 36?

A. That is December 20th to 30th, or 31st.

X Q. 29. December what?

A. It is the last ten days in December, 1916.

X Q. 30. Now, let us take the other one, 193, I don't read on this statement what it is.

A. Slime vanner tailings plant, I think you will see it up there.

X Q. 31. It is written in ink?

A. Yes, sir.

X Q. 32. Does that commence with January 1, 1916?

A. It does.

X Q. 33. I notice that the fourth item of the fourth horizontal line is shown in blank. What is the reason for that?

A. The fourth item and also the 20th item are blank. I could not find the ten day reports for that, but I have the daily operations which go to make up that ten day report and I did not have time to figure it in order to tabulate, but I have it.

X Q. 34. Will you supply that deficiency in order to complete the record?

A. Yes, sir.

X Q. 35. That applies to all of the blanks, these two sets of blanks, does it not?

3506 A. Yes, sir.

X Q. 36. Now, as to the other one, the vanner concentrate retreatment plant, I notice that there are some blanks?

A. The last blank or period 36, I did not tabulate that because on the last day of December in this plant we added over one per cent of oil and it would not be fair to add that in that tabulation.

X Q. 37. But the other blanks you can supply just as you did before?

A. Yes.

X Q. 38. I wish you would do so.

A. All right.

Mr. Williams: I think with the same reservation—of course I have not had time to study these—I will suspend the cross-examination.

Witness excused.

J. T. SCHIMMIN, called as a witness in behalf of the defendant, being first duly sworn, testified as follows:

Direct examination.

By Mr. Scott:

Q. 1. Will you please state your full name?

A. J. T. Schimmin.

Q. 2. What is your occupation?

A. Mill superintendent for the Butte & Superior Mining Company.

3507 Q. 3. And how long have you had experience with flotation concentration?

A. Since in September, 1912.

Q. 4. In the operation of the Butte & Superior flotation plant I will ask you whether the following factors are liable to variation: first, the tonnage fed to the plant per unit of time?

A. Yes.

Q. 5. And how about the kind of oil?

A. Yes.

Q. 6. That varies too?

A. Yes.

Q. 7. And is there any variation in the duration and degree of agitation and aeration?

A. Yes.

Q. 8. Is that variation marked, the speed of agitation?

A. Yes, it is.

Q. 9. Over what periods does it vary—vary from higher to lower I mean?

A. Oh, no, the amount of agitation does not vary. It is constant.

Q. 10. The agitation and aeration are constant?

A. Yes, they are constant.

Q. 11. The kind and quantity of reagents other than oil? Is there some variation in that?

A. But very little.

Q. 12. Temperature of the pulp?

A. Very little variation in the temperature.

Q. 13. And is there some variation in the percentage of moisture in the feed?

3508 A. Yes, at times there is.

Q. 14. And how about the variation in the percentage of sulphide in the feed?

A. Yes, that varies to a certain extent.

Q. 15. And how about the variations in the quantity of oil used?

A. Well, that varies slightly, depending upon the tonnage and so forth.

Q. 16. Now, in your plant when using the minimum efficient quantity of oil, if all the conditions I have just mentioned remain constant except percentage of water in the feed and the quantity of oil used what change do you make when the percentage of water in the feed increases?

A. We increase the oil.

Q. 17. Now, in your plant when using the minimum efficient quantity of oil if all conditions remain constant except percentage of sulphide in the feed and the quantity of oil used what change do you make when the percentage of sulphide in the feed increases?

A. Increase the oil.

Q. 18. Have you compiled a tabulation from your records showing the relations between percentage of sulphide and oil, quantity and per cent of water and oil quantity?

A. I have, yes, sir.

Q. 19. Did you compile this or have it compiled under your direction?

A. I have had it compiled under my direction.

Q. 20. From the original records of the company?

3509 A. Yes.

Q. 21. And you are able to testify that this is an accurate statement of the matters set forth?

A. Yes.

Q. 22. And you do so?

A. Yes.

Mr. Scott: I offer this tabulation entitled "Butte & Superior Mining Company, data compiled from original records of flotation plant operations, month of November, 1916, flotation plant feed."

Tabulation admitted in evidence and marked Defendant's Exhibit 194.

Mr. Scott: You may cross-examine.

Cross-examination.

By Mr. Williams:

X Q. 23. In the second column in the tabulation produced by you, exhibit 194, the first column following the date, the first item is 1.67 pounds of oil per ton?

A. Yes.

X Q. 24. Is that new feed?

A. That is new flotation feed, yes; new feed.

X Q. 25. And what oil was used then?

A. Pine oil.

X Q. 26. And throughout the month of November that is here tabulated what oil was used?

A. Pine oil with the exception of—I don't remember ex-
3510 actly—it was about 36 hours I think when reconstructed oil, compounded oil, was used.

X Q. 27. Can you tell me when this was, these operations, because having a new and totally different oil introduced it might introduce a variable factor?

A. No, I can't tell you the exact date without looking it up.

X Q. 28. Will you look that up?

A. Yes.

X Q. 29. Of course that would take a day and a half and might seriously change one of these figures; you appreciate that?

A. Yes.

X Q. 30. What other reagent or reagents were used during this period of November, 1916?

A. Sulphuric acid and copper sulphate solution.

X Q. 31. Was the amount of sulphuric acid and copper sulphate solution variable during this period?

A. Slightly, yes.

X Q. 32. To what extent did it vary? Take first the sulphuric acid?

A. Well, it would probably vary from six and a half to eight and a half pounds per ton.

X Q. 33. And how the copper sulphate?

A. Probably two one-hundredths of a pound of metallic copper, equivalent to two one-hundredths of a pound of metallic copper.

X Q. 34. And how about its variation?

A. That is the variation.

X Q. 35. What was the absolute assay then?

3511 A. From eight one-hundredths of a pound to one-tenth of a pound.

X Q. 36. Now, I notice that you have compiled the zinc sulphide from the assay of zinc. It is true, is it not, that there are small quantities of other sulphides in your ore?

A. Yes.

X Q. 37. And these other sulphides are variable, are they?

A. The sulphides vary but little. In fact, you might call them almost constant.

X Q. 38. And what would be the constant or nearly constant, approximately, that would have to be added to the zinc sulphide to represent the total sulphides in the ore?

A. You mean the percentage that should be added to represent the total?

X Q. 39. Yes.

A. I should say between six and seven per cent.

X Q. 40. Have you a tabulation covering this month giving the other factors such as appear on the large sheet containing the Butte & Superior operations which has been put in evidence? Have you a table of that character?

A. Yes, I haven't got it with me though.
X Q. 41. Will you produce it and let me have it?
A. Yes, I will.

Mr. Williams: The cross-examination is suspended.

Witness excused.

3512 R. A. CONRADS, recalled, testified as follows:

Direct examination.

By Mr. Scott:

Q. 1. Mr. Conrads, will you tell me whether in the operation of the flotations plant where you are employed the following factors are liable to variation tonnage fed to the plant per unit of time?
A. Yes, sir.
Q. 2. That is subject to variation?
A. It is subject to variation.
Q. 3. How about the kind of oil used? Is that also a variable?
A. The kind of oil used is variable to a degree. That is we have certain standard oils which we ordinarily use, but at times we are forced to make changes, though we do not make any radical changes in that ordinarily.
Q. 4. Is there much or any variation in the degree of agitation or aeration?
A. No, that is fixed with us.
Q. 5. And the variation in kind and quantity of reagents, other than oil?
A. There is a variation in the quantity, but not in the kind, there is not.
Q. 6. How about the temperature of the pulp?
A. We run at atmospheric temperature. We don't artificially heat the pulp.
3513 Q. 7. You don't use artificial heat?
A. Do not.
Q. 8. So it is subject to variation from any sources whatever other than the climate?
A. It is subject to slight variations, but it is not noticeable or hardly considerable.
Q. 9. Does the percentage of moisture in the feed vary?
A. It does, yes.
Q. 10. Percentage of sulphide in the feed?
A. That also varies.
Q. 11. Quantity of oil used?
A. And the quantity of oil is variable.
Q. 12. Now, in your plant when using the minimum efficient quantity of oil and all conditions that I have just mentioned remain constant except percentage of water in the feed and the quantity of oil used, what changes do you make when the percentage of water in the feed is increased?

A. Increase the amount of oil.

Q. 13. In your plant, while using the minimum efficient quantity of oil and all conditions remain constant except percentage of sulphide in the feed and quantity of the oil used, what changes do you make when the percentage of sulphide in the feed increases?

A. We increase the oil also.

Q. 14. You have made a tabulation, have you, from your records showing the relation between percentage of sulphide and oil quantities, and percentage of water and oil quantities?

3514 A. Yes.

Q. 15. During the period covered by this compilation was the same character of oil used throughout?

A. There was a certain variation. I made one chart which covered the entire period of the plant during which they have treated or retreated low-grade concentrate, the kinds of oil have varied in that, and I have taken these monthly averages and made a compilation on that basis. I have another in which the kinds of oils were not varied a great deal. It is practically a crude mineral oil with creosote. That is for a 28-month period, September, 1914, to December, 1916, inclusive.

Q. 16. You compiled this yourself from the original records?

A. I did, yes, sir.

Q. 17. And it is correct?

A. To the best of my knowledge it is correct.

Mr. Scott: I will offer this tabulation entitled "Utah Copper Company, Magna Plant, Metallurgical Department, data compiled from statements giving average results by months of operations of vanner concentrate flotation plant, September, 1914, to December 1st to 24th, inclusive, 1916."

Tabulation admitted in evidence and marked Defendant's Exhibit 195.

Q. 18. You also compiled this second statement which you handed to me?

A. I did.

3515 Q. 19. And is it correct and accurate?

A. To the best of my knowledge and belief, it is.

Mr. Scott: I offer the third statement produced by the witness, entitled "Utah Copper Company, Magna Plant, Metallurgical Department, data compiled from original records of operation of vanner concentrate flotation plant for the year 1915, etc."

Table admitted without objection, marked Defendant's Exhibit 196 (two sheets).

Q. 20. You compiled this third statement from the original records, did you?

A. Yes, I did.

Q. 21. And is it true and accurate?

A. Yes, to the best of my knowledge and belief it is.

Mr. Scott: I offer the third statement produced by the witness, entitled "Utah Copper Company, Magna Plant, Metallurgical Department, data compiled from original records of operation of vanner concentration flotation plant for the year 1916."

Table admitted in evidence marked Defendant's Exhibit No. 197 (2 sheets).

Mr. Scott: Mr. Conrads wants to correct an answer that he made before, Mr. Williams.

Q. 22. What was the answer?

A. There is just one question; in reading over my former testimony, in that, while my answer is correct, it is not quite as accurate as I would like to put it, and I would like to make a correction accordingly.

3516 Mr. Williams: You may do so. Will you give me the number of the answer?

The Witness: Yes, sir; it is page 560, question No. 306. You asked: "That sludge tank, is that full—full to overflowing?" and my answer was "No, I have never seen the sludge tank full; that is, it is a perfectly clean fall; that is, it does not interfere in getting the samples." I want to correct that statement simply in this, that I have a very few times seen that sludge tank overflowing a little froth. Now, if you will look at the previous questions, we were considering the matter of sampling the circulating feed, and where that sample is got, and when you asked the question I had in mind the sampling, and my answer there was with that in mind. I have never seen the sludge tank full of pulp, and very few times have I seen it overflowing froth, and we are very careful in taking that sample that it is never full, so as to interfere with the sampling of the stream as it drops from the launder into the tank. I wanted to be a little more accurate in that, as I noticed that, while practically true, it was not as accurate as I wished it stated. That is all, Mr. Williams.

3517 Cross-exmination.

By Mr. Williams:

X Q. 23. Now, in the first of these tables which you produced, exhibit No. 196, you gave the variation in the kind of oil; in this period, covering from January 12th, 1916, to December 23d, 1916, you made, of course, certain variations in the oil, did you not?

A. There were some variations, yes, sir.

X Q. 24. Do you think you have previously testified as to what those variations were?

A. Well, I gave you, if you will remember, a note of the variations asked for, and, as I stated in my direct examination, there were no extreme or radical variations. We used through that time, practically all of the time—I think I am safe in saying all of the time—crude petroleum oil with creosotes. Now, those creosotes were varied to a certain degree, though not radically.

X Q. 25. And all of those creosotes, of course contained soluble constituents?

A. Yes, sir.

X Q. 26. And the other oil, the crude petroleum oil?

A. It is a top petroleum oil, that is, a crude oil with the lighter groups removed; practically all the gasoline and kerosene are removed.

X Q. 27. Did you ever determine whether or not there were any soluble constituents in those oils?

3518 A. No, but from the very nature of them, it is safe to say that there would be practically none.

X Q. 28. Could you give me any figures as to the percentage of soluble constituents in the creosote?

A. No, I could not.

X Q. 29. Now, the second table that you have produced, exhibit 197.

A. That is the third table, Mr. Williams.

X Q. 30. Well, the one that I am referring to is No. 197, data compiled from the original records of the operations of the vanner concentrate flotation plant for the year 1916.

A. There are two of those for that year. Exhibit No. 196 covers the days in the year 1916 on which the percentage of solids in the flotation feed was not under 31% nor over 33%, while in exhibit 197 the compilation embraces the days of the year on which the percentages of mineral—that is, 100% minus the per cent of the insoluble matter, in the feed, was between 24.5 and 25.5.

X Q. 31. Are these the assay returns of the insoluble that you give in this table, exhibit 197?

A. Yes.

X Q. 32. And is it true of your ore that the assay returns of insolubles give all of the constituents except the sulphides?

A. No, but I took that for the reason that, on account of the nature of our ore, I think that this will more nearly represent it—

3519 that is, represent the total amount of percentage of mineral than by attempting to calculate it from the copper and iron of the assay.

X Q. 33. What are the constituents of your ore, which are present in the form of sulphides?

A. Principally pyrite, chalcopyrite and chalcocite, with certain other minerals entering into it in a minor degree. The reason that I did not calculate them on the basis of the assay for copper and iron was because the ratio of the amount of chalcocite and chalcopyrite and pyrite, for example, are not constant from one day to another or from one time to another.

X Q. 34. Is the ratio of sulphide—or is the proportion of sulphide clearly indicated by the amount of insoluble in the assay returns?

A. It is not absolutely accurate, though I believe that it is a more accurate way of getting that ratio than any other that I know of, without analyzing, and every one specially, which analyzes we do not have.

X Q. 35. That is, with the assays before you, you selected this as

the one that would give us the nearest estimate of the proportion of metalliferous mineral in the ore; is that correct?

A. The proportion of sulphide or metalliferous mineral in the ore, yes, sir. While that is not absolutely accurate, I take it because I think it is the most nearly accurate of any way that we have at hand.

X Q. 36. Now, will you give me a typical assay, so that we can see all the conditions that entered into your determination?

A. You mean to take one of these days and give you the
3520 assays?

X Q. 37. Yes.

A. What day would you like, Mr. Williams?

X Q. 38. Take about the middle of the period. I don't see the months.

A. The month is indicated by the first figure of the two in the left-hand column.

X Q. 39. Well, we will take about the middle of July. About 6/24—June 24th will answer.

A. June 24th. The heading on that day assayed 6.64% copper, 6.54% iron and 75.10% insoluble. The per cent of solids is on the sheet at 29.65, and the pounds of oil per ton were 3.40.

X Q. 40. And that is all your assay shows?

A. In the heading, yes, sir.

X Q. 41. You might complete it by giving me the assay of the concentrates and of the tailings on that day.

A. The concentrate assayed 25.98% copper, 23.25% iron and 16.13% insoluble. The tailing assayed .35% copper and .76% iron.

X Q. 42. Percentage of insoluble, have you that in the tailing?

A. No, sir; we never run the tailing for insoluble.

X Q. 43. Now, let us take September 1st.

A. September 1st, 1916; the heading was 7.68% copper, 6.08% iron and 74.70% insoluble. The concentrate, 29.12% copper, 20.62% iron and 18.43% insoluble; tailing, .24% copper, and .51% iron.

X Q. 44. Now, let us take the last date, December 18th.

3521 A. December 18th, the heading assayed 7.60% copper, 5.78% iron and 74.93% insoluble; the concentrate, 30.95% copper, 20.32% iron, 16.60% insoluble; and the tailing, .138% copper and .56% iron.

Mr. Williams: The cross-examination of Mr. Conrads will be suspended for the present until we have further studied the tables.

FRANK JANNEY, after being duly sworn as a witness for defendant, testified as follows:

Direct examination.

By Mr. Scott:

Q. 1. State your full name.

A. Frank G. Janney.

Q. 2. What is your occupation, please?
A. General superintendent of mills for the Utah Copper Company.
Q. 3. The mills at Garfield, Utah?
A. At Garfield, Utah.
Q. 4. They are known as the Magna plant and the Arthur plant, are they not?
A. They are.
Q. 5. How long have you been occupied in practising flotation, or how long does your knowledge of flotation extend?
A. Since the early part of 1912.
Q. 6. And you have been continuously engaged in the
3522 practice or trying out of flotation processes ever since?
A. I have.
Q. 7. Will you state whether it is true that in the flotation process the following factors are liable to variation; first, the tonnage fed to the plant per unit of time.
A. Yes.
Q. 8. And how about the kinds of oil used?
A. They are variable.
Q. 9. You might state to what extent that is variable, and what kind of oil is used generally.
A. Well, they are variable simply in the kind, that is all.
Q. 10. How about the duration and degree of agitation and aeration?
A. It is constant.
Q. 11. And the kind and quantity of reagents other than oil?
A. Variable.
Q. 12. And the temperature of the pulp—of course I refer to your own operations.
A. I understand. We operate at atmospheric temperature.
Q. 13. And percentage of moisture in the feed?
A. Variable.
Q. 14. The percentage of sulphide in the feed?
A. Variable.
Q. 15. How about the quantity of oil that you use?
A. Variable.
3523 Q. 16. Now, in your plant, when using the minimum efficient quantity of oil, if all the conditions we have just mentioned remained constant, except percentage of water in the feed and quantity of oil used, what change do you make when the percentage of water in the feed increases?
A. Increase the oil.
Q. 17. And in your plant when using the minimum efficient quantity of oil, if all factors remain constant except percentage of sulphide in the feed and quantity of oil used, what change do you make when the percentage of sulphide in the feed increased?
A. Increase the amount of oil.
Q. 18. Have you visited several different flotation plants and observed their operation?
A. I have.
Q. 19. Are you familiar with the way in which these flotation

operators generally tell when they need to change the quantity of oil—when the quantity of oil should be changed?

A. I am in a general way.

Q. 20. In a general way what does occasion their adjustment of the oil quantity?

A. The dilution.

Q. 21. Any other thing?

A. The agitation and the amount of sulphide.

Q. 22. You have made some tables, haven't you, of the operations conducted under your charge, showing the relations between percentage of sulphide and oil quantities and percentage of water and oil quantities?

3524 A. I made one tabulation of the variation of the pounds of oil to percentage of sulphides only.

Q. 23. Is this tabulation made from your original records?

A. It is.

Q. 24. And you have personal knowledge that it is correct?

A. I have.

Mr. Scott: I offer this tabulation entitled "Utah Copper Company, Arthur Plant, metallurgical department, data compiled from original record of operation of flotation plant treating original slime feed."

Tabulation admitted in evidence and marked Defendant's Exhibit 198.

Q. 25. Will you just explain, Mr. Janney, what this tabulation is intended to exhibit?

A. This tabulation was gotten up from which a graphic chart was drawn and refers only to the pounds of oil per ton and the percentage of solids. The copper and iron values having no value in the graphic charts.

Q. 26. You mean the graphic chart which was made?

A. From this data.

Q. 27. Was data only on the dilution?

A. The same thing.

Q. 28. And no account was taken of the mineral?

A. No.

Mr. Scott: You may cross-examine.

3525 Cross-examination.

By Mr. Williams:

X Q. 29. As I understand it this chart that you have produced represents proceedings with an invariable oil mixture, is that right?

A. Invariable oil mixture.

X Q. 30. Now, what was that oil mixture?

A. 95 per cent Barrett number 4, 5 per cent Yarvan pine.

X Q. 31. Barrett number 4 is what kind of an oil?

A. Creosote oil.

X Q. 32. And that had a soluble constitutent?

A. It has.

X Q. 33. And the pine oil is to some extent soluble, in the proportions used?

A. It is.

X Q. 34. And other conditions then, thickness of pulp and richness of ore, did they have any influence on the increase or diminution of the amount of oil?

A. Change in feed and tonnage.

X Q. 35. Anything else?

A. No.

X Q. 36. Of course you are referring to the operations in your plant?

A. Yes.

X Q. 37. How about the variation in the amount of gangue in the feed;—doesn't that vary the oil proportions?

A. It does through the dilution.

3526 X Q. 38. Aside from the dilution and considering it as a matter of solids, the amount of gangue in the feed is quite an important item in itself, is it not, in varying the amount of oil?

A. I don't know just exactly what you mean.

X Q. 39. I suppose that may be said to be the reverse of the condition of richness of ore. That is to say if your ore contains more mineral and less gangue, that is one condition?

A. Yes, sir.

X Q. 40. Now you might have a condition where there was less mineral and more gangue, then the ore would not be as rich?

A. Yes.

X Q. 41. Now, under these conditions you have to change the oil?

A. Yes.

X Q. 42. So that to that extent the increase and diminution of gangue is a variable although related to the decrease and increase of metalliferous mineral? That is right, is it not?

A. Yes.

X Q. 43. Now, how about the character of the gangue? Doesn't that change the oil proportion?

A. Not on our ore.

X Q. 44. Not on your ore?

A. No.

X Q. 45. And you refer to the operations of the Arthur plant?

A. Yes.

3527 X Q. 46. How about the fineness of the grinding of the gangue? Isn't that a factor?

A. Not on our ore, I do not think.

X Q. 47. That is to say that is not a variable in your ore?

A. It is not a variable, very constant.

X Q. 48. You testified, did you not, in the suit of the Minerals Separation Limited against the Miami Copper Company?

A. I did.

X Q. 49. And in your testimony there you described the great troubles that you had in correcting the faults of the plant of the Butte & Superior Copper Company, the flotation plant, did you not?

A. I did.

X Q. 50. You might give me the period when you were correcting these faults, generally?

A. From July of 1912 to——

X Q. 51. (Interrupting.) Just to refresh your memory, what you answered in the Miami case was: "I was sent to investigate the Butte & Superior process in the early part of 1912. I think it was in the month of June or July; maybe May; I will not be positive about that point." I have read your testimony correctly?

A. Yes, sir. I looked it up since then, it was July.

X Q. 52. And how long did you continue in this struggle which you so fully outlined in the Miami case of getting that plant into good working condition?

A. About the middle of 1913; I am not positive when I
3528 made my last trip to Butte. I know it was in the year 1913.

X Q. 53. Reading from your testimony in the Miami case, question 94: "Now, will you tell us the date upon which the results were of such a character as to make it certain that flotation was advantageous? A. It was in the month of April or May of 1913." Have I read your testimony correctly?

A. Yes, sir.

X Q. 54. And is that a correct statement?

A. It is.

X Q. 55. I also read you question 95: "And what did you do in the way of oils? A. We tried several different kinds of oil, oleic acid, various grades of oleic acid, pine tars and pine oils and wood tars. Q. 96. Can you make a statement as to the comparative results of using pine oil and oleic acid? A. With pine oil we found that we could get a very good grade, but we were unable to make a good tailing. With oleic acid we could make a very good tailing, but only a fair grade." Have I read your testimony correctly?

A. You have.

X Q. 56. And that needs no correction, I take it?

A. None at all.

Mr. Williams: That is all.

Redirect examination.

By Mr. Scott:

R. Q. 57. Were you in charge of the operations of the Magna plant from September, 1914, down to July, 1915?

3529 A. I was.

R. Q. 58. You are familiar with this tabulation that has been made, I take it?

A. Yes.

R. Q. 59. Are you in a position to verify these reports, state that they are accurate and true?

A. To the best of my knowledge they are.

Mr. Scott: There is no further objection to these.

Mr. Williams: No further objection upon the ground that the witness is not able to testify to the facts.

(Exhibit 35.)

Witness excused.

Prof. ARTHUR FAY TAGGART, recalled, testified as follows:

Direct examination.

By Mr. Scott:

Q. 1. Professor Taggart, have you made any investigation based on the facts set forth in these compilations which are in evidence as exhibits 191 to 198?

A. I don't know the exhibit numbers. I have made some compilations, some graphs based on the data that has just been presented regarding the relation between the percentage of oil and the dilution of the pulp and the percentage of sulphide in the pulp.

3530 Q. 2. Well, what conclusions have you arrived at from your investigation?

A. I have arrived at the conclusion that—or at least I have confirmed the conclusion that there is a relation and a very decided and strong relation between the percentage of sulphide in the feed or the variations in this percentage and the variations in the quantity of oil required, other things being constant, and also between the variations in the dilutions of the feed and the quantities of oil required, other things being constant. I am offering this data rather to satisfy Mr. Williams I think in regard to an inquiry in my previous testimony as to whether these statements that I was making were not wholly theory and as to whether it was possible to confirm them with any experimental data. He did not include mill operations, but the mill operations being more closely at hand, I investigated those and I have here a series of charts which show unmistakably a direct relation between the pounds of oil used and the dilution of the pulp, other factors being constant, and the pounds of oil and the percentage of sulphide in the pulp, other things being constant. Now I wonder if I might explain a little bit here regarding the curves compiled from empirical data. If your honor will notice this particular sketch which we will offer later you will see that there are points scattered around over this sheet and that through them I have drawn a curve. The curve does not go through every point but is the average curve of these points. It has been put through according to the accepted method of putting curves through

3531 points representing the result of investigations and such curves leading, if desired, to the formulation of empirical formulæ to represent the relation between the two particular variables investigated. Now, just to show you that every fact represented there does not lie directly on the curve I would like to cite a couple of cases which are familiar to all of us and which are instances of the use of such data for the formation of curves representing the

average of this data. The first one is the case of the range of temperature with the seasons. For various parts of the country there are well established average curves of temperature ranging from season to season, and if I may represent here about how one of these curves goes I think it will perhaps make it clear. If each one of these divisions represents a particular division of the year as for instance, if this represents February, this March and this April, May, June, July, August, and this represents degrees of temperature, we will call these, we will say forty, fifty, sixty, seventy, and up to eighty, we know that in certain communities at least from February through March, through April and May there is a gradual increase in the temperature which would be represented in some such fashion as this. Suppose that during February the average temperature were 40°; during March the average temperature were fifty degrees, then a point would be placed there, and during April it were 55 degrees, another point would be placed at the ordinate representing May, and if in May it were sixty and June sixty-five, and July
3532 seventy, then the curve that would represent the average would be drawn in actually a straight line for the average through these points. Now, nobody would expect, looking at that average curve that all the days in March were going to have a temperature of 50 degrees. If we plotted along here the temperature of the days in March they would be found to spot around the average in that case; and, similarly, if we plotted the days in April, and it is quite easily recognized that there is an average advance of temperature through these months. Another case, and one upon which a great deal more money is invested than this particular case of temperature, and one in which the ranges are much greater, is the case of life insurance premiums based on the average life, and life insurance premiums have decreased as the years have gone on, due to the fact that the average age of people in certain lines of life is increasing. Now, we know very well that if we draw a curve representing—take one thousand people, and if we draw a curve representing the average age of life that it will not mean at all that certain people are going to live until exactly that age. There are going to be deaths of course from an hour or a shorter moment after birth to even very considerable old age. These are going to range through large distances and yet for each year that those data are compiled there are going to be deaths all through these different ages and yet the average curve through there will show that as we go from 1912 to 1913 and from 1913 to 1914 there is a gradual increase in the
3533 average age; and that average curve is so well recognized that the life insurance companies expend or promise to expend enormous sums of money on the computations made by their actuaries. These computations are merely straight lines, average lines drawn through these experimental points. Now, I hope with this explanation that I may be able to show the results of plotting some of these facts that have just been represented, and to show your honor that the curve drawn through in each particular case represents the average of all these points which are plotted on the graph. The first curve which I have here is that of the Utah Copper Com-

pany, Arthur plant, flotation treatment of original slime feed for the months of September and October, 1916, omitting October 8th to 12th inclusive when the oil mixture was changed, the data being compiled from original records of operation, these records being already in evidence, presented by Mr. Janney.

Mr. Scott: I offer the table just described by the witness.
Mr. Williams: No objection.

The graph admitted in evidence and marked Defendant's Exhibit 199.

A. Now, if your honor will notice this particular curve it increases, that it rises toward the right. If you will notice down at the bottom of this sheet are certain numbers and written above that are the words "pounds of new oil used per ton of original feed," and that these numbers increase towards the right. That
3534 means a point which was plotted on the chart anywhere above that three, for instance, represents that three pounds of oil were used. That is if a point appears anywhere along this line vertically above the three, it means that three pounds of oil were used. Then, on the left hand margin of the sheet are two series of numbers, those to the left reading 80, 85 and 90, and representing the per cent of water in the feed. They read upward 80, 85 and 90, indicating that that particular square increases upwards. The complimentary square of that is put beside it, that is 10, 15 and 20. The three numbers reading downwards representing percentage of solids in feed. Of course the statement of our constants, if put in terms of percentage of solid in the feed, would be that the pounds of oil necessarily varied inversely as the percentage or solid in the feed; but it is rather easier to speak of the direct variation, rather than of the inverse variation. Now, your honor will notice that as this curve passes to the right it rises and if we take first any point on the vertical line running upwards, this one representing one pound of new oil used per ton of original feed, and then run over to the left at that level, the square representing the percentage of water in the feed, you will see that the percentage of water there is about eighty-two per cent. In other words, for a percentage of water eighty-two per cent of the total pulp fed to the mill an average amount of one pound of oil per ton of solid feed to the mill was used. If now your honor will go out to the vertical line over the number
3535 two on the lower scale and follow that line up to its intersection with the straight line which has been drawn and then follow from that point to the intersection to the left and read on the scale of percentage of water you will see that that reads about eighty-four and a half. In other words when the dilution of the pulp has increased from eighty-two to eighty-four and a half, the average amount of oil necessary in that particular mill has increased to two pounds. There is a direct relation there, other things being approximately constant, between the amount of oil needed and the amount of water present in the pulp. That same thing is borne out in all these other statements, as I will represent the curves to you.

Q. 3. Now, Professor Taggart, would it be practicable to explain, so that we can get some idea of the manner of laying out these curves and what these numbers mean on the different dots?

A. Yes. The numbers I may say on the curves correspond to the numbers in the left-hand column of the particular sheet which goes with it. In other words, those are the data to which these particular dots correspond. For instance, if we take the number 6 at the far left of the chart. The numbers corresponding to this on this sheet are "pounds of oil per ton, 0.82." That is on the sheet entitled "Utah Copper Company, Arthur plant," and there being only one of those.

Q. 4. Is that the last one?

A. The last one that was offered.

3536 The Witness: Now, if you will look at this No. 6, you will note that the dots to the left there refer to the date of September 6th, and there in the next to the last column is "Pounds of Oil per Ton, 0.82." Now, going to the scale at the bottom of the sheet and moving out here to a point between 0.75 and 1—The point 0.82 represents the distance to the left at which you must plot this 0.6. Now, corresponding with 0.82 there is in the last column the number 19.30, which represents the percentage of solids in the feed; and going then on to the scale at the left end of the chart between 15 and 20 in the column "Percentage of Solids in Feed," down near the 20 in order to get at 19.30,—That is the altitude of this charge at which this same spot should be plotted.

Now, if we follow that horizontally, then, from that point and vertically upward from the point right over 0.82 which we have previously located, at the intersection of those two lines is the point where that figure 6 is to be plotted. In other words, if we work this thing backwards, you take the point 6, and you can read that it means 0.82 pounds of oil were used, and the percentage of solids in the feed was 19.30, and the same method is followed in plotting, as it is called, all these points from the sheet, and all these different values from this sheet of the different dots represented in their proper position by this series of dots on the chart, showing by their number the particular date which they represent—those numbers which are separate being for the month of September, and those which

3537 are preceded by the number 10, representing the different days in the month of October.

This particular chart extends from the first of September to the end of October, 1916.

Now, the method of putting the curve through those points is one that was developed by an engineer by the name of Steinmetz, who is probably the most famous experimental engineer in the country. He is one of the experimental engineers for the General Electric Company, and one of the lines in which he has been very much interested is the mathematical side and the experimental side of electricity. Now, his idea is that, when you have a series of points such as this presented here, and wish to plot through them an average curve, as, for instance, if I plot points all around here in that fashion—Of course for rough work you can just size up by the eye

what straight line will approximate the average of those points—and it would pass through in some such fashion as that. If, however, you want accurate results, the method recommended by Steinmetz is to divide these points approximately into equal lots, as it were, that is, into two lots containing approximately equal numbers of points at either side of a line which is approximately at right angles to the point, and the line should be—the type formula for a straight line is Y, and the formula is, Y equals AX plus B. Now, if it is necessary, before you plot that particular curve, to determine the coefficient A of the variable X, and the constant term, B.

3538 that is done by taking each one of these points to the left of your line separately, and substituting in the value of Y, which is the distance of the point upwards from this horizontal line, which we will say in this case is approximately 2, and substituting in also the corresponding value for X, which in this case would be 1, and we will then have this equation: 2 equals 1A plus B.

Now, if you repeat that for all the points at the left of that line—I will take one other point here for the purpose of illustration; suppose we take the point here, and the value of Y there would be approximately 2.2, and the value of X would be about 3—Of course all these numbers that I am approximating here are taken accurately and directly from the table of the curves—We would have then, for the second equation by which we hope to determine A and B, the equation: 2.2 equals 3A plus B.

Now, if we add together that series of equations, we get, 4.2 equals 4A plus B.

We now pass onto the other side of the line, and repeat the same method of treatment, and I will take two points over there; I will take 2, because this will throw a line in there with at least an average of what I have taken. We will take this point, in which case Y will equal approximately 4, and the equation will be, 4 equals 3.5A plus B, and for the point here we will have, 2.5 equals 5A plus B, and if we take these points together, we get the equation 6.5 equals 8.5A plus 2B.

3539 Now, by solving those equations we have now two independent equations in A and B, and it is a rule that if you have two independent equations and two unknowns, it is possible, by simultaneous solution of the two equations, to determine the two unknowns. You then go about this solution in this fashion: subtract one from the other, and you get 4.5A equals 2.3, or that A will be equal to $\frac{2.3}{4.5}$, which is easily turned into a decimal number.

Then, given that result, you get that B is equal to something over 1, which I will indicate by 1 plus. Then we go back to this equation and substitute the values of A, and we find that Y is equal to $\frac{2.3}{4.5}$X plus 1 plus—that is, something larger than 1; I don't think it is necessary to go through the calculations. All those curves have been calculated through in that fashion; that is the equation and the cor-

rect equation for averaging the lines to those points, and it can then be plotted in the light of that equation in some such fashion as that

The Court:

Q. 5. What is the object in the end, to show the varying relations between these several factors?

A. Yes, sir, to show that the oil——

Q. 6. To show that there is some constant curve?

A. Absolutely, and it shows in all these charts, not only in regard to the dilution, but in regard to the percentage of sulphide.

3540 This is the line of the average when the percentage of sulphide was held practically constant, while some of these other curves were plotted when the dilution was held practically constant, and the only things plotted were the percentage of sulphide and the amount of oil, and in those cases the same kind of an equation is shown.

Q. 7. Going right back to this exhibit 198,—I want to get onto these curves—On the 28th of September you have got a .99 copper, .93 iron and 12.79 solids?

A. Yes.

Q. 8. Now, you had less metal, so you must have had more water in the solution?

A. More water, yes.

Q. 9. And consequently your oil content runs pretty high?

A. Yes, sir.

Q. 10. Then if we take the one for the 6th, you have got more copper and more iron and more solids?

A. Yes, sir.

Q. 11. That would mean of course less water?

A. Yes.

Q. 12. Your oil content runs down pretty low?

A. Yes.

Q. 13. It is a pretty wide variation, and this is an attempt to balance all these factors?

A. Yes, that is what I say. It is the same question here; it is the same problem which confronts the actuary. He has people dying, children, middle aged people, old people, dying at all ages, yet he balances—

[Copy of cover of volume 7 of transcript of record.]

3540½ United States Circuit Court of Appeals for the Ninth Circuit.

No. 3081.

BUTTE AND SUPERIOR MINING COMPANY, Designated as Butte and Superior Copper Company, Limited, a Corporation, Appellant,

vs.

MINERALS SEPARATION, LIMITED, a Corporation; MINERALS SEPARATION AMERICAN SYNDICATE, LIMITED, a Corporation, and Minerals Separation North American, a Corporation, Appellees.

Substituted Pursuant to Order Filed March 19, 1918, for Incorrect Copy Filed November 10, 1917.

TRANSCRIPT OF RECORD.

Volume 7.

(Pages 3541 to 4212, Inclusive.)

Upon Appeal from the United States District Court for the District of Montana.

Filed Mar. 19, 1918. F. D. Monckton, Clerk.

3541 —these deaths and gets an average expectation of life for a man of a given age, and on that average enormous sums of money are invested. Now here is a set of data with variations certainly not so great as in the case of the actuary; and while it is impossible for the mind to grasp the whole situation of these detailed figures, and all you can do is to pick exceptions—the general trend of results is convincingly shown by this curve representing the average.

The Court: I think I understand what the witness is endeavoring to arrive at now. I will have to get out my old algebra and brush up a little.

Mr. Scott: Professor, you may mark that diagram on the other side so as to keep it in the record.

Diagram 24 of Professor Taggart, admitted in evidence marked Defendant's Exhibit No. 200.

By Mr. Garrison:

Q. 14. Are all these charts the same?

A. One half of them show the relation of dilution to oil, and the other half show the relation of the amount of sulphide to oil.

Q. 15. But they all proceed on the same principle?

A. Yes, sir.

Mr. Garrison: I don't see why it is necessary to go into the details of those things.

The Court:

Q. 16. This line which you curve through there, that is done to give the detail of these things, and then you connect them up?

3542 A. That is a chronological curve. Now, I have some of those same data presented chronologically, and there you get that variation; but if you desire, for instance, in this particular chart, the average curve, we proceed in exactly the same way that I proceeded here, and the average curve would come in in some such fashion as this. This would be a much more difficult problem, because the average curve is practically on a straight line, and we would have to fool around a long time to get the particular curve line.

The Court: Well, I think it is 5 o'clock. If there is any way you can facilitate the examination by these other gentlemen, you might do it. You expect to put in each one of these with an explanation, I suppose?

Mr. Scott: That is our intention, yes, sir.

Adjournment until Wednesday, May 2nd, at 10 a. m.

Wednesday, May 2nd, 1917—10 o'clock a. m.

Prof. TAGGART on the stand.

Direct examination resumed.

By Mr. Scott:

Q. 17. I think you were explaining the first graph when we closed—the first one you mentioned, I mean.

A. Yes. Your honor will remember that we were talking about the relation between the per cent of water in the feed and the
3543 pounds of oil per ton of feed used, at the Arthur plant of the Utah Copper Company, and I have shown that, as the percentage of dilution of the feed increased—that is, as the percentage of water in the feed increased, other factors remaining approximately constant, that the pounds of oil necessary to get a satisfactory recovery increased also.

Now, I have some other curves. Here, for instance, is a curve of the Utah Copper Company, Magna plant, the curve No. 3 of the Utah Copper Company, Magna plant. You will notice there again that the ordinates, or the values of the vertical scale are the same, the percentage of water in the feed; and the abscissæ, or the values of the horizontal scale are the same, namely, the pounds of oil per ton of feed and that the same variation as before holds, namely, that the amount of oil necessary increases as the amount of water in the feed increases.

Again in curve No. 1 of the Utah Copper Company, Magna plant, is shown the same relation between the percentage of water in the feed and the pounds of oil necessary per ton of feed.

Now, at the plant of the Ray Consolidated Copper Company at Hayden, we have exactly the same relation between the percentage of water in the feed and the pounds of oil per ton.

Here is a curve showing the work of the Butte & Superior Mining Company, plotted in exactly the same way; the percentage of water in the feed, as the vertical scale, increasing upward; the pounds of oil per ton of feed, as the horizontal scale, increasing to the right, and there again the same relation is shown.

It will be noted also on that particular chart that the points
3544 hug the line a little more closely. If there had been any question about some of the previous curves, of the particular curves that were put through, as to whether that particular curve was justifiable or not, certainly when we get points which hug the line as closely as these do, and as I will also show that the points do in the case of the Chino Copper Company, then it is further confirmation of our right to place the curve as it has been placed on some of the other charts.

By the Court:

Q. 18. Your oil variations are rather narrow in this last one.

A. Yes, sir.

The Court: Your oil variations are rather narrow in this last one?

A. Yes, sir. You see in all of these curves it has been laid down that the oil should be the minimum efficient quantity. There is a very broad band in the quantity of oil through which you can do efficient work. In other words, there is no critical point in the quantity of oil. For an investigation of relations then, in order to escape the leveling effect of this broad band through which you can do efficient work, it was necessary to work with the minimum quantity which will give efficient results; and that is what has been done in compiling all of these curves. The results have been taken for periods when the minimum efficient quantity was used.

I now have the last, I think, of the curves showing the relation between the dilutions and the pounds of oil per ton and I will say that it is entirely similar to the previous curves presented.

3545 Q. 19. Will you hand me a copy of each of these so that I may offer them, each of the graphs representing the relation of oil to dilution? We offered yesterday the one for the Arthur plant, and that is now in evidence as exhibit 199. That is the diagram showing the relation of oil to per cent of water in the feed.

A. These are the ones.

Mr. Scott: I now offer the graph for the Utah Copper Company, Magna plant, showing the relation of amount of oil to percentage of water in the feed.

Graph admitted in evidence and marked Defendant's Exhibit 201.

Mr. Scott: It is noted that the exhibit just admitted for the Magna plant covers the amount of oil used as shown by data taken from the record of the year 1916.

I now offer the graph for the Utah Copper Company, Magna plant, showing the relation of pounds of new oil to the percentage of water in the feed, the same being based on data taken from the records of flotation plant by months, from September 14th, to the 24th of December, inclusive, 1916.

Graph admitted in evidence and marked Defendant's Exhibit 202.

Mr. Scott: I now offer the graph for the Ray Consolidated Copper Company, showing the relation of pounds of oil per ton in feed to the percentage of dilution of the feed, the same being based on

3546 data taken from original records of flotation slime vanner tailings plant for periods of ten days for the year 1916.

Graph admitted in evidence and marked Defendant's Exhibit 203.

Mr. Scott: I now offer the graph for the Ray Consolidated Copper Company, showing the relation of pounds of oil per ton of feed to the percentage of dilution of feed, the same being based on data from the original records of vanner concentrate flotation plant for ten day periods during the year 1916.

Graph admitted in evidence and marked Defendant's Exhibit 204.

Mr. Scott: I now offer graph for the Chino Copper Company,

Hurley plant, showing the relation of pounds of oil used per ton of feed to the percentage of water in the feed, the same being based on data taken from the original records of the vanner concentrate plant, month of November, 1916.

Graph admitted in evidence and marked Defendant's Exhibit 205.

Mr. Scott: I offer a graph for the Butte & Superior Mining Company, showing the relation of pounds of oil per ton of flotation feed to the percentage of water in the feed, the same being based on data compiled from the original flotation records, for the month of November, 1916.

Graph admitted in evidence and marked Defendant's Exhibit 206.

3547 Q. 20. Have you compiled similar graphs representing the relation of the amount of oil to the amount of sulphides in the feed?

A. I have.

Q. 21. Will you produce them?

A. Now, the first one that I would like to call attention to is that No. 2 of the Utah Copper Company, in which the percentage of total sulphides in the feed is plotted as the vertical scale and the pounds of oil necessary per ton of feed is plotted as the horizontal scale. The curve had been drawn—or the straight line has been drawn, through these points in the way that was explained yesterday, and in the same way that the straight line was drawn of the relation between dilution and pounds of oil necessary. And the same relation shows, that is, that as you increase the richness of the feed to the flotation plant, other conditions remaining approximately constant, that the amount of oil necessarily increases. I have here also a curve plotted from the records of the Butte & Superior Mining Company, showing the same relation between the percent of zinc sulphide in the feed and the pounds of oil necessary.

I have also a curve of the Chino Copper Company, showing the same relation to exist between the percent. of sulphides in the feed and the pounds of oil used per ton. It will be noticed on this curve that at the right hand side there are four points which are apparently decidedly erratic; that is, they use a larger amount of oil than is apparently necessary for the percentage of sulphide in the
3548 feed on those days; but on those four days the average dilution of the feed was higher than the average dilution on the other days; in other words there the dilution came in and raised the amount of oil necessary. Had the dilution been the same as it was, those four points would move right back onto or very near the straight line which has been put through as representing the relation.

I have next a curve showing the relation between the percent of total copper and iron and the pounds of oil used per ton of feed at the Ray Consolidated Copper Company. This curve was drawn to show the relation between the metal, rather than the sulphide, because the sulphide of course increases with the metal. Changing these figures to sulphide, would merely mean changing the vertical scale, but would not alter the slope of the curve, and it was rather

more easy to calculate this thing, and not so many assumptions had to be made in counting the total copper and iron—no assumptions, in fact, had to be made in plotting those figures, while if we had attempted to change these figures into sulphide, some assumptions would have had to be made.

A definite relation exists between the total copper and iron and the percent of total sulphides of copper and iron, and the same relation will hold between the percent. of total sulphides of copper and iron and pounds of oil per ton of feed, and the amount of total copper and iron, in relation to pounds of oil per ton of feed. It
3549 still shows the tendency, that the amount of oil increases as the percentage of sulphide in the ore increases.

The same remarks hold in regard to the curve marked No. 3, of the Ray Consolidated Copper Company. I am again showing here the percent. of total copper and iron as against the pounds of oil per ton, this being from the slime vanner tailing plant, while the preceding one was from the concentration plant. Here the slope of the curve is very decided, and exhibits again this relation.

Now, in relation to these last two curves, I would like to call the court's attention to another confirmation of our idea—or of the fact that the amount of oil necessary for efficient concentration increases as the percent. of sulphide in the ore increased.

In the two tables which were presented by the Ray Consolidated Copper Company plant, we have the data given concerning the vanner concentrate retreatment plant and the slime vanner tailing plant. In the case of the slime vanner tailing plant the pounds of oil used per ton range from 1.82 as a maximum to .63, if I read this table correctly, as a minimum; in other words, somewhere in the neighborhood of one pound per ton as an average minimum efficient quantity of oil. The total percentage of copper and iron in the feed ranges in 2%—I think it is not necessary to pick out the maximum and minimum pounds of it, but all these figures are within a range of 2%; in other words, for one pound of oil that is used, the feed contains about 2% of total copper and iron
3550 sulphide. Now, in the concentrate retreatment plant, the same kind of oil is used. The sulphides are of course the same sulphides, and the gangue present is of course the same gangue; in other words, here we have all conditions the same, except the amount of sulphide present in the feed and the amount of oil used.

In the vanner concentrate retreatment plant the total percent of copper and iron ranges from approximately ten to fourteen percent., and the amounts of oils necessary range from about 2.7 up to about 4 pounds; in other words, there, with all the conditions the same except these two variables, percentage of sulphide and pounds of oil per ton, we have this increase in the pounds of oil as the percentage of the sulphide increases.

It is necessary in any such comparison as this that the kind of oil and the kind of sulphide compared be kept the same. It is possible, as we all know, to treat Butte & Superior ore with one, two or three pounds of oil per ton. There is somewhere in the neighborhood of

twenty per cent of sulphide in Butte & Superior ore. And, if we go down to the Utah Copper Company, where the feed in the slime treatment plant runs down in the neighborhood of perhaps one to two per cent sulphide in the feed, the minimum efficient quantity of oil there, certain kinds of oil, will be in the neighborhood of one or two pounds per ton, which would look like a contradiction; but, if the same oil and the same sulphide are used together, that are
3551 shown in this Hayden plant, between the slime vanner plant and the concentrate retreatment plant, and in the relation shown in the curves, it is necessary then, other things being constant, to increase the quantity of oil as the percentage of sulphide increases.

Mr. Scott: If you will hand me copies of those last graphs showing the relation of oil to sulphide, I would like to offer them so as not to get them confused.

I offer the graph for the Utah Copper Company, Magna plant, showing the relation between pounds of new oil per ton of original feed and percentage of sulphide in the feed, the same being based on data taken from the records of the year 1916, January 1 to December 24, inclusive.

Graph admitted in evidence and marked Defendant's Exhibit 207.

Mr. Scott: I offer the graph for the Butte & Superior Mining Company showing the relation between pounds of oil used per ton of flotation feed and percentage of zinc sulphide in the feed to flotation plant, same being based on data compiled from original records, month of November, 1916.

Graph admitted in evidence and marked Defendant's Exhibit 208.

Mr. Scott: I offer the graph for the Chino Copper Company flotation plant showing the relation between pounds of oil used
3552 per ton of feed and percent of total sulphide in the feed, the same being based on data taken from the original records of vanner concentrate flotation plant, month of November, 1916.

Graph admitted in evidence and marked Defendant's Exhibit 209.

Mr. Scott: I offer the graph for the Ray Consolidated Copper Company showing the relation of pounds of oil per ton of feed to the percentage of total copper and iron in the feed, the same being based on data taken from the original record of flotation slime vanner tailings plant, for the periods of ten days each during the year 1916.

Graph admitted in evidence and marked Defendant's Exhibit 210.

Mr. Scott: I offer the graph for the Ray Consolidated Copper Company, Hayden plant, showing the relation between the pounds of oil used per ton of feed and the per cent total copper and iron, the same being based on data taken from original records of the vanner concentrate flotation plant for the ten day periods during the year 1916.

Graph admitted in evidence and marked Defendant's Exhibit 211.

Mr. Scott: One question I would like to ask you.

Q. 22. In the first place, the dots are located on the chart,
3553 their position upward from the base line being determined by the dilution or amount of sulphide, as the case may be; and their position to the right of the other base line being determined by the amount of oil used?

A. That is right.

Q. 23. And the locating of the curve afterwards is a matter of mathematical computation, after an accepted formula?

A. That is right.

Q. 24. Have you ever conducted any operations yourself using amounts of oil running into high percentages?

A. I directed a couple of tests at the plant of the Utah Copper Company recently concerning which I have the data here.

Q. 25. At which plant was that?

A. At the Arthur plant.

Q. 26. Will you just describe that operation?

A. The first one of these tests was in one of the regular Janney mechanical machines arranged 13 cells in series, taking the full feed, with no circulation.

Mr. Williams: I think, if your honor pleases, that this is an ex parte experiment.

Mr. Scott: I will have Mr. Frank Janney testify that he invited your representatives to see this test but they didn't come. It was during the time that your representatives visited Salt Lake.

Mr. Williams: I know nothing about it; counsel knows nothing about it.

3554 Mr. Scott: They were invited to attend.

Mr. Williams: Apparently here is something that was conducted at a plant while our representatives were present?

The Witness: No, no.

Mr. Scott: No.

Mr. Williams: I don't really know what it is about, but it seems to me here is an effort to put in an ex parte experiment.

Mr. Scott: The offer was made to perform these tests in their presence while they were there, at the most opportune time to do it, for them.

Mr. Williams: I reserve the right to object until I find out what it is all about.

A. This is a test run at the plant of the Utah Copper Company, the Arthur plant, on their machine called No. 1, which was a 13 cell Janney mechanical machine with two emulsifiers at the head of the machine, in the plant retreating vanner concentrates. The full normal feed of this particular machine was taken during the period of the test, and the middlings of the machine were not circulated. The duration of the test was one hour, and I made previous observations before starting this test to determine that representative

results could be obtained in a run of one hour's duration—not the best results, but representative results. I have here some extra copies of this which I can distribute if you wish before the discussion begins. It will be noted that the heads or the feed to the machine ran 4.7 per cent total copper; that the feed contained 42.26
3555 per cent solid; the tailings contained .8% copper; the concentrates contained 14.15% copper, 10.5 per cent iron, 52.50 per cent insoluble. The ratio of concentration was 3.42. The per cent of indicated extraction on the copper was 87.95; the pounds of oil added per ton 21.78; the reagent used was the so-called calura of the Utah Copper Company plant and the oils used were the viscous heavy oils of the standard Utah Copper Company oil mixture. In other words, they were a part of the oil mixture used at the Utah Copper Company which is labeled under certain circumstances as inert. The interesting part of the test then being that, using these so-called inert oils, which it has sometimes been assumed are added purely for the purpose of cheaply bulking the amount of oil used up to more than twenty pounds per ton, that even on so short a test as this it was possible to push the recovery up to 87.95. I have also here the record of another test that was made——

Mr. Scott: I will offer this report produced by the witness of this operation just described by him.

Mr. Williams: I object to the testimony of the witness in regard to this and to the report itself for the reason that it is shown to represent an experimental operation conducted at a plant at a time when our representatives were there and not conducted in their presence nor with any opportunity for them to observe and check up the results. It seems to me that there should be a limit placed upon this kind of experimenting, and that when the circumstances
3556 are such that it could have reasonably been conducted with opportunities for inspection and it does not appear that there was any effort to so conduct it, that the testimony should be rejected as not worthy of consideration by this court or any of the courts that may follow it.

The Court: Well, does it appear that your representatives were there?

Mr. Williams: Yes, and so far as we know it appears that they were very busy taking specimens, and couldn't give the matter any attention. There is no evidence of that either at all, no. It does not appear in evidence that our representatives were there. Nothing has appeared. It is all statements.

The Court: You are making an objection and stating facts that do not appear here.

Mr. Williams: Then I say here is a test which——

The Court: Well, the particulars will all come out eventually, and for the sake of the record the court will allow this testimony to be introduced. He has already testified to it orally. If the circumstances are such that it should not receive any consideration the court will give it none. The objection will be overruled.

Report admitted in evidence and marked Defendant's Exhibit 212.

The Witness: I have here another test that was run at the same time as the one just testified to. I will give you copies of the description.

Q. 27. This test represented upon this memorandum you
3557 have just produced was performed under your supervision, was it?

A. Yes.

Q. 28. And what plant was it performed in, and what machine?

A. At the Arthur plant of the Utah Copper Company, on the same machine as the previous test and on the same feed; that is, the vanner concentrate, using the full 13 cells of the machine, the full normal feed to the particular machine, and the middlings not circulated.

Q. 29. The material simply went through the machine from one end to the other?

A. Yes, and contrary to the usual practice in the plant, the middlings were thrown directly in with the concentrates, rather than being sent back to the Dorr thickeners and back to the plant for retreatment.

Q. 30. What was the reason?

A. In order to prevent building up an oil circulation in the middlings and consequently getting different results from those that would be indicated with the exact quantity of oil that we were adding.

Q. 31. In other words, giving back the exact quantity of oil you added, without increasing it through local circulation?

A. Yes, sir. In this particular test the feed came in at the rate of 460 tons per 24 hours, the copper in the feed being 4.875%, the feed containing about 42% of solid matter. The tailings ran .462%
of copper, the concentrate 13.3% of copper, 10.2% of iron
3558 and 39.2% insoluble. The ratio of concentration was 2.91, and the percentage of indicated extraction, based on the copper, 93.78. The reagent used was the so-called Calura, and the oil was the usual oil mixture of the Utah Copper Company Arthur plant when treating vanner concentrates, being 59% smelter fuel and 30% Jones oil—those are the heavy viscous oils—10% American Creosote No. 2, and 1% Yaryan pine.

The interesting part of this experiment or test is the amount of oil that was added per ton of ore, which was 249.83 lbs. The concentrates contained, by analysis, 491 lbs. of oil per ton, and the tailings contained by analysis 23.16 lbs. of oil per ton. During the conduct of the test I made continual observations as to the distribution of the froth on the cells and as to the character of the tailings from the machine. When this test was started the machine had been run for a considerable length of time previously without any oil being added, and the froth had died down on the surface of the cells until there remained nothing but occasional scattered bubbles on each and all of the cells. Very shortly—ten minutes after the oil was added, froth was appearing, a rather voluminous oily appearing froth was on the cells down to about No. 7. As the test pro-

gressed, the froth, a voluminous working froth, appeared on the cells on down in the machine until at the end of the test froth was being removed in considerable quantities, and when I speak of froth
I am making a distinction as between froth and the stray
3559 bubbles that are present under ordinary operations on the later cells—Froth was appearing the full length of the machine. At the same time that that happened I had a sample taken of the tailing and examined the sample very carefully, first before any vanning had been done, and then I vanned down slowly, watching for oil in the tailing, and watching also most particularly for the so-called Cattermole granules, which are agglomerates of sulphide particles. There was a large amount, as is obvious, of course, from the analysis, of oil in the tailing. I took the different particles of oil between my fingers and worked them over—There was no pretense or no appearance whatsoever of granulation and balling up into small agglomerates—but to assure myself that there was not any prejudicial amount of sulphide in this oil, I took the particles between my fingers and rubbed my fingers together and got no more grit from the oil than one will necessarily get if he takes some muddy water between his fingers; in other words, there was no semblance whatsoever of the Cattermole effect in the tailings of the machine.

The percentage of oil in the tailings assures us that in each successive cell throughout the machine there was contained more than 20 pounds of ore per ton of feed to that particular cell, and the frothing, which differed only in apparent oiliness throughout the machine—The first cell was of course the most oily appearing—and as
we moved down the cells, the oily appearance decreased.
3560 Apart from that, and apart also from the volume, there was no difference whatsoever in the character of the froth—I should perhaps say structure of the froth rather than character; there was some difference in the character if the richness should be so described.

Q. 32. Will you compare the froth which you have just described in the matter of structure with that which you have seen when the apparatus is operating on less than 1% of oil?

A. The structure was just the same of course; the bubbles consisted of films of contaminated water, containing solid matter.

Mr. Scott: I offer the report produced by the witness of the operations just described by him at the Arthur plant of the Utah Copper Company. I may state that we will produce Mr. Janney, as I said before, who will testify that he invited the representative of the plaintiff to see a test such as described by the witness, but, in order to remove all misunderstanding, we now offer to repeat this test for their benefit and in their presence, with access to all of the details and every opportunity to check it.

Report of test No. 2 admitted in evidence marked Defendant's Exhibit No. 213.

Mr. Williams: We accept the offer of the defendant, because that

seems to be the only solution. These are very interesting and perhaps instructive tests, if we can find out all about them.

Mr. Scott: We have a witness who will testify to still
3561 another test, and we extend our invitation to cover that also, a test at the same plant, or anyway in the same town. I think it is at the same plant.

The Witness: Yes, at the same plant.

Mr. Williams: So that can all be done in one trip?

Mr. Scott: Yes. You may cross examine.

Mr. Williams: I think as far as these particular tests are concerned, your honor, that the right to cross examination had better be deferred until we have seen them repeated and know about them.

The Court: I am beginning to think that this case shows no prospect of ever ending, if witnesses are called and recalled and transferred to Utah to make tests and come back again.

Mr. Scott: Maybe they could do that over Sunday, your honor, so as not to delay matters.

The Court: Proceed.

Mr. Garrison: Your honor is not going to make us cross examine on those tests held not in our presence?

The Court: Is this the way patent cases are usually tried?

Mr. Garrison: I think not, your honor.

Mr. Scott: I only extend this invitation as to this particular test in the interest of peace. Mr. Janney invited these representatives to see this, and they said they could not stay over to see it.

Mr. Kremer: Wasn't Professor Fulton your representative?
3562 Mr. Williams: Professor Fulton was one of our representatives.

Mr. Kremer: He was invited to attend this test.

Mr. Williams: Just about the time he was going to take his train.

Mr. Kremer: I don't know anything about his train; he was invited.

Mr. Garrison: That is not the important matter. Professor Fulton had no authority to attend this test. Counsel governed these matters, and he had to get back to be present the next morning in court Now, to be fair and to have all the testimony brought in that ought to be brought in, I assume that these tests are relevant and important points in this case. If not, they should not be admitted to it at all. They are, however, self-serving declarations by these gentlemen who get up and qualify as experts here, but whether they have knowledge of what they are going to do—They bring in things written on a paper which are utterly uncross-examinable by us, and they produce what they assume to be proper testimony. I conceive that nothing could be less productive of fairness and nothing could put the other side at a greater disadvantage than we are put in this matter.

It of course deserves no special credit on our side that we have not been captious. We realize that this case is of great importance; that in its various aspects it has been to the Supreme Court of the United States and before other various high courts of justice

3563 in this country. We realize that your honor does not intend to exclude any evidence which, by any possibility could have any bearing—any proper bearing on the issues in this case, and with that view we sympathize; we do not want this case tried so that any court of law which passes upon it has any doubt——

The Court: Is it your opinion that such evidence should not have been admitted?

Mr. Garrison: Should not have been admitted at all, sir. I should like to speak of that if it was not a ruling that your honor has already made.

The Court: Well, have you not said that you intend to put in some test of this kind?

Mr. Garrison: No, sir; we do not propose to put in any test not made in the presence of the court, do we, Mr. Williams?

Mr. Williams: We propose to put in none that were not made in the presence of the opposing parties, and as far as we know we do not propose to put in any tests except those made in the presence of the court.

The Court: These tests and experiments close to the beginning of a trial, I imagine are not entitled to very much weight. I think there is a case in the Supreme Court where they virtually intimated that they should not be accepted, especially if they were made out of the presence of the other party, and samples were not taken.

Mr. Garrison: Yes, sir; I was just going to call your honor's attention to that.

3564 The Court: And I think that the court should say something about it, for fear they should be held competent further along the line.

Mr. Garrison: Exactly; if they are incompetent we are absolutely confronted with these figures, not knowing anything about them, or what the ingredients might have been or anything, and we simply can not cross examine about them.

The Court: The court has admitted these things with the statement that if the court thinks it is not entitled to consideration, it will get none. But I may make up my mind later on that these things are entitled to consideration. The plaintiff, however, can not say the court thinks them entitled to consideration, and I can see how that would be.

Mr. Garrison: The first case that I ever tried, I relied upon the first point and thought that I was perfectly safe on the second point. The court held with me on my first point and against me on my second point, and threw me out of court, and I have been rather wary ever since. We think these tests should be excluded; they were performed out of our presence and without our being advised of what was done. If your honor is willing to adjourn court sufficiently long for them to conduct tests in our presence at certain places, we will submit to that ruling, and of course, I want to suggest very earnestly to your honor the impropriety of permitting evidence of this kind, which there is no way for us to check.

3565 The Court: On what theory do you offer it, Mr. Scott?

Mr. Scott: It is the universal practice in patent cases to hold

that, whether an experiment is exparte or inter-parte goes to its credibility only and has nothing to do with its admissibility; and where the other side are invited to attend, and either do or do not, even the element of credibility is removed from the situation altogether.

The Court: The invitation to a mere employe four or five hundred miles away would be hardly sufficient.

Mr. Scott: They were there for the express purpose of investigating the operation of this plant.

The Court: Well, it stands in the record, and you will be given an opportunity to meet it. If you can not meet it, of course the court takes that into consideration, but certainly there must be a limit. You are not to keep the court waiting while different sets of witnesses go from here to Utah to carry on tests and report back about them, and the other side must come back and check them up. We will never get through here at all at that rate. The year's work of the court will be dislocated completely. I appreciate that you must have all the time necessary to try this case, but that does not mean that you may have all the time that you think is necessary. There is quite a distinction there.

Mr. Kremer: The offer was made, and the objection was
3566 interposed that they did not have the opportunity to check the test, and we made the offer to repeat it, and they accepted it.

The Court: Well, the court has something to say about that; it has not surrendered the entire control of this case to counsel.

Mr. Kremer: I appreciate that, but they have about 14 men whose names were presented here, any one of whom could go there and inspect it. I don't think it is going to delay the trial at all.

Mr. Garrison: I would like your honor to rule upon the question of the competency. This witness has not shown that he knows how much tonnage was put into the machine or how much oil or how much calura, or anything else; he has not qualified as a metallurgist; and yet he comes here in person and offers testimony which covers a plant half as big as this court house, and pretends to know just what took place at every point in that plant,—and if he does not know, his testimony is not competent——

The Court: What are the qualifications which this witness gave; it has been some time ago.

Mr. Garrison: He has not qualified as a metallurgist. He tells the amounts of the heads and tails and tonnage; he tells the amount of acids and insolubles and all that in his own person. He is an entire concentration of the apparatus of that plant upon this most critical day. Now, if that kind of testimony is admissible, the rules heretofore governing the courts upon the character of evidence that can be given in court are all wiped out. This is the rankest
3567 hearsay, and yet we are met with his bald statement that, in respect to very important points in this case he is going to lay down certain dicta, which, unfortunately for us, cross examination can only cause him to reiterate and emphasize.

The Witness: I think I can qualify, your honor, in the ways that the gentleman questions.

Mr. Scott: The witness has already qualified.

The Witness: I also observed the weighing——

Mr. Garrison: One moment, please. I am not arguing this case with the witness; I am arguing it with your honor.

The Court: Well, I allowed the witness to testify at length as to what were his qualifications originally.

Mr. Scott: He testified to having an education in mining engineering at Stanford University, to several years' practical experience in his profession——

The Court: These facts that he is testifying about now appear, and if he is not qualified to testify to those, it will be enough to show on cross-examination whether he is qualified or not.

Mr. Garrison: I understood his testimony to be that he had been at plants before flotation was introduced.

The Court: With reference to the fact, does he know how much oil and other things were used, and as to the analysis, etc.? Both parties have allowed that to go in from the beginning. I don't know about this. You can develop it if you can.

3568 Cross-examination.

By Mr. Williams:

X Q. 33. What knowledge have you as to the feed that entered the flotation plant at the operation which you called test No. 1?

A. As to what particular characteristic of the feed, Mr. Williams?

X Q. 33-A. What knowledge have you of that feed—not information, but knowledge?

A. As to what particular characteristic?

X Q. 33-B. Well, what do you know about it.

The Court: He is proceeding to tell.

A. I know as to the quantity in so far as the tonnage sample, which is the ordinary method of determining the quantity, will tell. I watched the tonnage sample taken; I watched the weights taken off the scales, I watched the timing.

X Q. 34. Then what was done to those tonnage samples afterwards in your presence?

A. The tonnage samples were dumped from the pan on the scales to the launder underneath the scales.

X Q. 35. Well, then, what further did you see being done with that tonnage sample.

A. Nothing.

X Q. 36. And yet you come here and say that the headings contained a certain proportion of solid, a certain amount of sulphide, and a certain amount of carbon—is that what you mean there?

3569 A. No, sir.

Q. 37. What is that "carb."?

A. That stands for carbonate.

X Q. 38. Now, where did you get all this knowledge from?

A. That was reported from the assay office.

X Q. 39. Did the assay office tell you what the condition of the water was in which that ore was diffused?

A. As to what particular characteristic?

X Q. 40. Was it pure water or was it water charged with a modifying agent?

A. It was water containing a very small quantity of contaminant in the shape of—which was determined—in the shape of oil. The Dorr tanks—or at least this machine had been run without return to the Dorr tanks for several days preceding this test at my direction in order that the amount of contaminant in the pulp going to the machine could be reduced as greatly as it was possible to reduce it. It is not possible to get it down so that there yet remains no trace of oil; but as I recollect, and I can produce assays if you so desire, the amount of oil in this feed coming to the machine was down to the neighborhood of one pound per ton of feed by assay. And I considered that as I was going to add somewhat more than 250 pounds of oil——

X Q. 41. No, we are on No. 1.

A. I see. As I was going to add somewhat more than twenty pounds of oil per ton to the feed that that wouldn't make any difference.

3570 X Q. 42. You think, having in mind the sequence of the operation and observing that the twelve and a half per cent—we will take it as twelve and a half per cent round figures?

A. Yes, sir.

X Q. 43. Now, the twelve and a half per cent operation was carried on first?

A. Yes, sir.

X Q. 44. From 7:45 to 8:45 p. m.

A. Yes.

X Q. 45. And this determination that you speak of and that you have not given us of the pound of oil in the feed water, that relates to that first operation, does it not?

A. And relates also to the second. We were sampling along in there right straight ahead in order to find out—to try to find out when that tank was ever going to get down to a point where it wasn't carrying a small amount of contaminant.

X Q. 46. Immediately after you did your twelve and a half per cent operation which loaded up your machine with oil, you did this 1.08 per cent operation?

A. Yes, sir.

X Q. 47. Which followed it by some forty-five minutes?

A. Forty-five minutes, yes, sir.

X Q. 48. What provisions did you observe between these two operations to remove that contaminated amount of oil that had flowed through the plant at the end of the operation which is marked test No. 2, and which ended at 8:45 p. m.?

3571 A. We stopped feeding oil to the machine, flooded the machine with water and scraped froth off until no more froth appeared than scattered bubbles, throughout the full length of

the machine, and then having brought the water down again to the point that the cells were not overflowing as to allow an opportunity for the froth to collect if it would collect, we ran machines in that way and found that no froth collected. In other words, there was not enough oil present in the feed, this small amount which I have mentioned shown by the assay, to cause any frothing or collection.

X Q. 49. That is to say there was not enough there to form any froth until you added your 1.08 per cent of the heavy oils and then it formed a froth?

A. Well, of course that is a way to put the question. I will answer it by saying that there was not enough there to form a froth; that there was not enough there to form a froth when small quantities of the mixed oil was added, because such tests were made at another period of my stay down there to determine whether 1.6 pounds of this mixture would do any work at all, and we discovered that it would not, and so there was not enough oil there even to do any work when this final mixture was added. Consequently I stand on this test marked No. 1, and on the statement that the effective part of the collecting agents and frothing agents present in that test was the 21.78 pounds of oil consisting of 66% smelter fuel and 34% Jones.

3572 X Q. 50. That is to say, in your opinion, all the work resulted from 1.08 per cent of the heavy oils and nothing resulted from the presence of something over a pound per ton of the dissolved frothing agent?

A. Yes, sir.

X Q. 51. And the test that you have numbered No. 2 was the first test that you made?

A. Yes, sir.

X Q. 52. And the test that you have numbered No. 1 was the second test that you made?

A. Yes, sir.

X Q. 53. Three quarters of an hour afterwards in the same machine?

A. These are renumbered for the convenience of the stenographer. The original number of these tests, if you would like to have them, were—the test which is No. 1 was No. 10, and the test which is No. 2 was No. 5. I have the data here in my notebook if you would like to see it.

X Q. 54. That is to say you made some eight other tests?

A. Yes, sir.

X Q. 55. Which you did not think it was worth while to bring here?

A. No, sir; we considered that we would be encumbering the record with repetition. There were quite a few data presented in the early days—I mean of the testimony, which I asked to see, as I wanted to see how these things were working, and we went down and ran a

3573 series of tests, which were purely confirmatory, as it were, of tests described in the previous testimony and we didn't think it necessary to encumber the record. If you like, however, I have the data on these tests and can produce it.

X Q. 56. Now you said that you had the analysis of the water?

A. Yes, sir, I have it,—I haven't got it here, but I can get it. These water samples were taken right straight ahead and are on the records of the Utah Copper Company during the time this work represents. I will send for them if you would like them.

X Q. 57. You haven't a specimen of the water, of course. You didn't take a specimen that you can give us?

A. No, sir.

X Q. 58. And all of the assays that are given here are the assays as they were given to you; you didn't make any of them yourself?

A. Oh, no, no.

X Q. 59. In fact, there was not a quantitative determination on these exhibits 212 and 213 that you made yourself?

A. Why, no.

The Court: Now, have you the stipulation?

Mr. Scott: I will read the stipulation which was entered into.

(Whereupon counsel read the stipulation previously entered into.)

Mr. Garrison: I drew that stipulation, and it seems to me I am entitled to state what I meant by it. I meant by the first part
3574 to limit the testimony entirely, as its language does, to testimony regarding operations at the Butte & Superior. I intended the latter to be confined, as its language seeks to, and I believe does confine it, to regular operations, such as those that have been admitted here and testified to by Mr. Engleman and other witnesses as mill superintendents, to which testimony I first made the objection that they had not their original reports with them. And this was intended to obviate the necessity of their bringing the original slips of paper upon which these reports were made. The language is: "Provided that either party may produce witnesses as to regular operations." Now, this, I consider, was not a regular operation. It was something carried on by this gentleman under his direction after several days of preparation and was in every sense of the word a test, and a test carried on out of court without any opportunity for us to be advised of what was about to be done and without any opportunity to take samples or to inspect or be present when the oil was going in or when the acids were going in, all of which things are matters of primary importance. If this gentleman was advised by some one standing at the oil spigot that they were putting in twenty pounds, he has to rely upon that, that is all he knows about it. If that person should turn the spigot off for a fraction of a minute, the operation is entirely different from what he thinks it is. This witness can, with entire honesty, testify to different things——
3575 The Court: I understand your point. Of course, you have your stipulation here. That represents it.

Mr. Scott: Counsel's remarks that he intended this to extend only to regular operations and not to special or test operations, is not in accord with the acceptance and interpretation that has been given to this stipulation. These reports which have been introduced by these other witnesses without objection, after this stipulation from counsel,

include test operations, operations to find out what will happen under this condition and under that condition, when this ingredient of the oil is omitted, and that when that ingredient of the oil is omitted. These things already received under this stipulation without objection from counsel include operations with extraordinary amounts of oil; and that is the only respect with the regard to which the present witness is going to testify that these operations differed from the ordinary operations, in exactly the respect that the evidence already introduced differs. What this stipulation means, it seems to me, is to be ascertained by how it has been accepted in this court, and how counsel have accepted it, not by what they say now, after both parties have acted upon the stipulation for two weeks.

Mr. Garrison: With respect to that, what has happened has been that when any one of these various allied companies have chosen to operate their mill for a series of days in a particular way, that becomes the regular operation of that mill for those days or
3576 weeks that they were so doing. It is an entirely different thing from a little experiment carried on by this witness under the circumstances here detailed.

Mr. Scott: There is one of these reports, your honor, which is a report entitled "Abnormal operations" and for the purpose of determining abnormal profits as distinguished from normal profits. Confessedly they are not, upon their face, what counsel denotes as "regular operations."

Mr. Garrison: That seems to be building up a principle of law upon the leniency of the parties upon the other side, which cannot be done.

Mr. Scott: You have waived that by stipulation.

The Court: Well, this stipulation, in its language, certainly contemplated regular operations and the result commonly understood as such, when regular records are kept as permanent files of the company. If they have departed from that somewhat, you have the benefit of that so far as it has gone, but I do not think it binds them continually. Personally, speaking as a court, I am inclined to doubt whether there is very much value to testimony of this character, experiments made while the litigation is pending, and as counsel says by allied companies, whom we can guess are confronted by somewhat the same condition as the defendant here, the same situation. And then, again, you were conducting these experiments twelve years after the patent and after three or four or five years of its
3577 practical working operation, when machinery and mechanical operations have been improved from day to day, when things have been made possible now, no doubt, that would not have been possible when this patent was granted and applied for. At the same time, the court has felt that such testimony might serve a limited purpose, as indicated in its various rulings, but at this time, this testimony in the court's judgment does not come within this stipulation, and in the face of this objection that it is hearsay, the court is bound to sustain it and will sustain it in reference to these last two experiments testified to by this witness. I think we are on the safe side.

Mr. Scott: We will bring the assayers and everybody else to prove it.

Mr. Kremer: I would like at this time to clarify the record by inquiring of counsel particularly if the stipulations in the Hyde record, the whole record being stipulated in, is not a stipulation in this case? It will guide us in our conduct, when it comes to the presenting of their case, because if we are not going to be bound—if they are not bound by the stipulation in the Hyde record, certainly we are not, and we of course will object—I am making this statement for the purpose of expediting matters, giving due notice so there will be no controversy when the question arises when their case is presented. If we are to be bound by the stipulations in the Hyde case, and we have thought we were bound by them, then it is unnecessary to present to this court, under that stipulation, the assayer and the
3578 gentlemen who made an analysis. We stipulated in this case that—correct me, Mr. Williams, if I misstate this, because I am stating it solely from memory—that assays should be received as presented on their verity unless specially challenged. Am I not correct in that? There isn't even that exception, Mr. Scott calls my attention to.

Mr. Williams: We will have the stipulation. There is a stipulation in the Hyde case and I understand that stipulation binds us in this case. We will start with that. There were several stipulations in the Hyde case but that stipulation——

Mr. Kremer: If that is going to bind us it must bind them.

The Court: Well, find your stipulation. That is what we are looking at right now.

Mr. Garrison: I have based none of my objections upon the assays.

Mr. Kremer: The objection was it was all hearsay.

Mr. Garrison: I said nothing, sir, in any of my remarks about assays. This is the first time the matter of assays has been mentioned. I said it was hearsay as to the amount of oil that went in and as to various other matters that this gentleman testified to, and I omitted everything about assays. I am perfectly willing to admit assayers' reports without the necessity of bringing them here.

Mr. Kremer: There is no essential difference between an assay for a mineral and an assay for oil; it is all assay.

3579 Mr. Garrison: I have not said a word about objecting to anything on the ground of assay. I am talking about the amount of oil that goes in to the mixture, which is not subject to assay at all. It is subject to standing at the spigot and seeing it go in. I myself stood at one of these mills and saw the spigot turned off and on. Whether it is turned on or off depends on a physical fact which can only be testified to by witnesses who were present and saw it. An expert is no more competent to testify what was happening on a floor above him than I am and I am not an expert.

Mr. Kremer: That is very true as far as it goes, but the only thing we are concerned in is the amount of oil that went in, and watching it go in is not the only way to determine that fact. An assay will determine its presence just as well as could be told at a spigot. We are certainly not called upon to discuss such an elementary proposi-

tion as that. Therefore, as this stipulation covers assays, it must cover all assays or it will cover none.

Mr. Scott: Here is one stipulation appearing upon page 70, by Mr. Williams: "It is noted that the tests above described by the witness, not having been made in the presence of opposing parties, the observations and conclusions of the witness are objected to as not the best evidence unless an opportunity is afforded to complainants to repeat these experiments by supplying the complainants with sufficient quantities of the ores used in the condition in which
3580 they were used in these experiments, and also, if necessary, of the other reagents. With this reservation, no objection is made to the assay figures upon the ground that the man who made the assays is not produced as a witness." Further that is put in in a more formal shape.

Mr. Kremer: We had a stipulation made preceding Dr. Chandler's testimony.

Mr. Williams: I think what Mr. Scott has read was the first appearance of a stipulation in there. The general understanding was that if the assayer who was known and whose work would be deemed acceptable to both parties did the assaying why he would not be called upon to testify. There may have been something in Dr. Chandler's testimony by reason of the fact that some one assisted him in the assay.

The Court: The court has ruled. You may proceed.

Mr. Kremer: Exception.

The Court: It will be noted.

Mr. Kremer: Your honor, I do not know—for the purpose of information, your honor has ruled this entire testimony out, do I understand that?

The Court: These two tests that the witness has testified with respect to.

Mr. Kremer: Will your honor permit us, so as to furnish a full statement of the record there—I don't know whether it would be necessary to submit a further offer to prove than that which appears in the record.

3581 The Court: If you desire.

Mr. Kremer: If so we will ask leave to submit it.

Mr. Williams: Now, I will cross examine the witness on the subject of curves.

X Q. 60. On exhibit No. 202, Utah Copper Company, Magna plant, No. 1, I find along the bottom of the chart the numbers are 10.0, 12.5, 15.0 and so up to 55, which is the last number and apparently 60, as the value of the last vertical line, and this is entitled "pounds of new oil per ton of original feed." Now, first, please tell me what is the table from whih this chart was made?

A. That was made from this Utah Copper Company, Magna plant, Metallurgical Department, vanner concentrate flotation plant, September, 1914, to December 24, 1916, inclusive, and on looking at this exhibit 195 I see that the pounds of oil per ton do not correspond at all.

X Q. 61. Is that in error?

A. I noticed that the draftsman apparently in copying moved the decimal point one point to the right. If you will move the decimal point one point to the left it will give you 1.0, 1.25, 1.50, 1.75, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0 and 5.5, and now the abscissæ are correct. That changes of course in no way the relations expressed that the quantity of oil required increases as the amount of water in the feed increases.

X Q. 62. Now, let us take curve No. 2, Utah Copper Com-
3582 pany, Magna plant, Exhibit No. 207. As I understand it, or as I read the curve, when the feed contains 24.2% of sulphides in the feed, no new oil is required. Does the curve show that?

A. That most certainly would be a proper reading of this curve as an average.

X Q. 63. That is to say you could operate without oil under those conditions?

A. No, I did not say that; I said that was a proper reading of that curve.

X Q. 64. Then, that being a proper reading of the curve, the curve shows that as — average, you can work without oil, is that correct?

A. The curve shows that, as an average, the amount of new oil per ton of original feed increases as the percentage of sulphide in the feed increases. Just as you can not predict from a curve of average life, that you are going to live to the age of average life.

X Q. 65. I appreciate that fact.

A. The same thing here.

X Q. 66. The same way in summer; if the mean average temperature of the month is 60, and a frost comes along and kills all the crop, you could not have predicted that frost from the mean average temperature?

A. Certainly not, but you can predict what the mean average temperature for the month is going to be, and in the case of life in-
surance you can predict with sufficient accuracy to invest
3583 large sums of money on your prediction.

X Q. 67. But your sums of money would not be invested unless you had so many of the variances that the average would be a reasonable basis for your prediction?

A. Of course not. No curves are useful unless that is the case.

X Q. 68. So that all that you have determined is, as far as these tables show, that there is, in all the variances for a certain day, a sort of average of these variances along the line that you have indicated?

A. Why, certainly; that is all you can expect from mill operations. These particular variations are much more impressive from the fact that, notwithstanding all the unavoidable variances in mill operations, due to the ignorance of operators and so forth and so on, that this big general trend shows up through the record; it is ex-

tremely impressive. If we should show these things with laboratory machines, where we could personally say that we are going to vary these two things only so much, and hold everything else absolutely constant, that of course would be confirmatory, but it would not be so impressive as this, where, notwithstanding all these variances which are without control, this great general trend shows throughout.

X Q. 69. Now, taking this average as a basis, I have followed your curve down to zero, and we reach the conclusion, I think, that we should not continue to represent the variations beyond zero.

3584 A. Of course it is a rule of all empirical calculations, that you should not carry them beyond the range of the data on which they are based. Nobody carries them beyond the range of the experiments from which he develops the curve; that is well recognized in all engineering.

X Q. 70. That is to say, these curves represent only the average of these experiments?

A. Exactly so. We can not carry any empirical law based on experimental data beyond the range of the experiment upon which it is based, or the results upon which it is based; but throughout those results, throughout the range of those data, this curve represents the law.

X Q. 71. And it seems to enforce the conclusion, does it not, that if, under similar conditions except the amount of oil, you change this average of about four and a half pounds of oil to twenty and a half pounds of oil, you are wasting oil, does it not?

A. Why, I think so, yes. I think we could most certainly have operated this—However, I think I had better correct that. If you can sufficiently increase your recovery to pay for the oil, then you are not wasting it. The matter becomes there one, however, of commercial operation rather than one of scientific technical operation, and other factors enter. If, by raising the oil quantity from four pounds to 20 pounds you can so increase your commercial recovery as to more than pay for the additional oil used, then it is not

3585 wasted. If the reverse is the case, then it is wasted.

X Q. 72. And if, by increasing the amount of oil you reduce the grade of your concentrates and diminish your recoveries, you would have to say that you are wasting oil?

A. If you decrease the net return to the company, you are most certainly wasting oil.

X Q. 73. You mentioned a formula of Steinmetz for passing a curve through a set of empirical data. Can you give me a reference to the Steinmetz publication which described that?

A. No, sir, I can not.

X Q. 74. Or any idea where it is to be found?

A. Why, I don't even know that. The thing goes so commonly by the name of the Steinmetz method of putting a curve through experimental points, that I have never taken occasion to look it up. I learned it when I was in college myself, and it has been called Steinmetz method, as I recollect, ever since. I can furnish you a reference, if you desire, by writing back to New Haven to men who

are dealing more particularly with the actual teachings of mathematics, and get it that way.

Mr. Williams: That is all, at present.

Witness excused.

3586 FRANK G. JANNEY, recalled for further

Direct examination.

By Mr. Scott:

Q. 1. Mr. Janney, did you have any communication with representatives of the plaintiff when they were in Salt Lake City and Garfield about a week ago?

A. I did.

Q. 2. And what was the nature of that communication and whom was it with?

A. I called Dr. Fulton by phone at the Utah hotel, and told him that we were conducting some experiments at the Arthur plant that I thought would be very interesting to him, and I asked him if he would like to come out and witness them. He said that he would discuss it with Mr. Chapman and let me know later. About 30 minutes later he called me on the phone and said it would be necessary for them to leave on the afternoon train for Butte, and that they would be unable to come out.

Q. 3. What day was this, Mr. Janney?

A. It was Sunday, the 22nd of April.

Q. 4. And about what time of day?

Mr. Williams: If your honor please, it does not seem to me that this testimony is relevant to any matters that are of record. Here is the fact: it is true, Professor Fulton and Mr. Chapman, who are not of counsel, happened to be in Salt Lake City, and Mr. Janney telephoned to them and said "I would like to have you come
3587 out—" and it was late in the evening apparently.

Mr. Williams:

Q. 5. It was in the evening, was it not, that you telephoned?

A. It was in the morning.

Q. 6. What morning?

A. Sunday morning about eleven o'clock.

Mr. Garrison: The experiment had then taken place.

Mr. Williams: The work of inspecting the plant had been finished. Counsel were not present, and they were under no direction from counsel, and counsel did not know of that fact until now in court, and the whole thing is now irrelevant and immaterial and we move to strike out the answer.

Mr. Kremer: I asked counsel the direct question if Mr. Fulton was their representative. Previous to that question being propounded the objection was interposed that their representatives, being

then in Salt Lake City, were not advised of these experiments or given an opportunity to witness them, and I asked if Professor Fulton was their representative and he said he was.

Mr. Williams: One of them.

Mr. Kremer: One of them.

The Court: What could one man learn from such an experiment if he were there? He could see only one part of it at a time. There would be many other parts and factors involved, of which he could not keep any check in a mill operation of that sort.

3588 Mr. Kremer: One man would be the man who would supervise the operation, and one man could supervise the observation.

Mr. Garrison: These experiments took place on Saturday, your honor.

The Court: The motion to strike will be granted.

Defendant excepted.

Witness excused.

Mr. Kremer: Mr. Williams asked Mr. Engleman to have a number of reports and data prepared for him. Mr. Engleman now has some data to supply to Mr. Williams, but before doing so Mr. Engleman, I believe, desires to correct something in his testimony.

Mr. Williams: His testimony of yesterday?

Mr. Kremer: I don't know; he just mentioned it to me when he said he had these papers for you.

EDWARD W. ENGLEMAN, recalled for further

Direct examination.

By Mr. Scott:

Mr. Williams:

Q. 1. I will ask the witness what page was the correction?

A. Page 1192—Well, 1191, really. Question No. 138 we will have to start with.

By Mr. Williams:

Q. 2. Proceedings of April 28th?

3589 A. April 28th.

Q. 3. You may make any correction that you have to make.

A. We will have to start with question No. 137 in order to get the complete understanding: "Q. Now, we will take the record for February 11th, 1917. A. Treated 463 tons heading, 456 tons tailings, 7 tons concentrates; 85.68 lbs. coal tar, 18.50 lbs. per ton of material treated. Q. 138. Now the assay. A. .680% copper in headings; .453 copper in tailings; 14.46 copper in concentrates; 50.20% insoluble; 7.20% iron." Now——

Q. 4. Now, do you go further?

A. Yes, sir.

Q. 5. I will read it: "Q. 139. Before I leave this particular plant what did you do with the material—What did you do with the kind and grade of material that you treat in this plant, before you installed it? A. This material was treated on our big permanent installation. Q. 140. What kind of concentration? A. Flotation concentration. Q. 141. No, before you had flotation. A. This material was going to waste. Q. 142. Now, in other plant for retreating vanner concentrate products, is that right? A. Yes"—Is that all you want?

A. Yes; that is the part I wanted to correct. We did not send this product to waste. It was treated by the smelter.

Q. 6. What you have given as vanner concentrates?

A. The vanner tailings went to waste, but the vanner concentrates did not go to waste before flotation.

3590 Q. 7. The vanner concentrates went to the smelter and the vanner tailings went to waste, is that right?

A. Yes, sir.

Mr. Kremer:

Q. 8. Is there anything else?

A. Why, I have some data here that was missing on the sheet presented.

Q. 9. I mean that you wanted to correct?

A. No.

Mr. Kremer: The paper is a tabulation of some matters requested by Mr. Williams on cross-examination, entitled "Ray Consolidated Copper Company, data compiled from Monthly State—" etc. We offer it in evidence.

Table admitted in evidence without objection marked Defendant's Exhibit 214.

Whereupon further hearing was adjourned until 2 p. m.

2 o'clock p. m., May 2, 1917.

Mr. Scott: In order to simplify matters and to avoid unnecessary taking up of time, I would like to get clear myself—Possibly the rest are clear but I am not—just exactly the grounds of the court's ruling in excluding the testimony of Professor Taggart. As I understood, the plaintiff's objection was on the ground that the experiment was ex parte; whereupon we offered to repeat the test

3591 and that was accepted. Then came an objection, as I understood it, on the ground that the evidence was hearsay, the witness not having personal knowledge of everything that had taken place, and when that objection was raised there was a discussion upon the subject of assays, and as I understood, counsel for the plaintiff stated that they did not insist upon proofs of assays. Now, as far as I have been able to sift it out, that seems to reduce the grounds that are relied upon to the weighing of the headings and

the tonnage of headings and so on, and just what is left I don't know.

The Court: The Court's ruling was on the theory that it developed that he had not sufficient personal knowledge of all the factors that were connected with this operation to speak of them other than by hearsay; that was all I had in mind at the time.

Mr. Scott: That is the way I understood the court's ruling, but as I further understood, and I think I am quite correct, counsel signified that they had no objection to accepting assays.

The Court: I think you have a stipulation to that effect; wasn't one read?

Mr. Scott: The court ruled that those were not regular operations but rather experimental operations of the mill.

The Court: When that matter came up, after the ruling was made, this testimony of Professor Taggart was held not to be within such stipulation. Then some one or both of them mentioned
3592 stipulations in the Hyde case, which are a part of this trial. Now, how far those stipulations go, I am not advised.

Mr. Scott: I wanted to be clear about whether this matter of the assays was waived, or whether we would be obliged to support this testimony by the individual assayers who performed the operation; and if counsel will state that, it will clear things up and simplify the further proceedings.

The Court: If you are not in accord about it—about what the stipulations cover, the court will have to rule on it.

Mr. Garrison: I don't know what the stipulations contain, myself.

Mr. Scott: We will proceed upon the assumption that all assays must be proved hereafter, and all other details and we will so be governed.

Mr. Williams: There is no ground for that assumption.

Mr. Garrison: I was waiting for Mr. Scott and Mr. Kremer to finish. What I said was that I do not base any objection or contention upon the verity of the assays; that my objection did not in any way attack the verity of the assay. I did not waive anything. I am perfectly willing to consider the matter with counsel on the other side and see what the stipulation should be to cover that matter, but I waive nothing. I simply said that my objection did not refer to assays, and the first time the word assay was mentioned, was by Mr. Kremer. That is the fact.

3593 The Court: Of course the court is ruling on matters as they are properly presented, but off the record, I would take it that the stipulation in the Hyde case goes to assays as they were presented, that they could present the result of an assay as from the assayer, but not from the oral statement of someone else; that is, that both parties would be inclined to accept an assayer's certificate, if he was a disinterested party. I don't know how far these stipulations go, because I have not read them.

Mr. Scott: I think they are too narrow to cover the present case, and that is why I made this inquiry; but my effort having failed, we will proceed on the assumption of presenting rigid proof.

Mr. Garrison: This is informal, of course, and I don't know exactly what is pending, but I assume that what is pending is your

honor's ruling. I want it thoroughly understood that my objection to the test made by Professor Taggart on the 21st of April is much broader than whether or not his basic information was hearsay. I do not wish any misunderstanding in respect to that, and I do not want counsel to say that they are surprised when I urge much broader and deeper and more radical objections than the one that is based upon hearsay. I endeavored to state that it seemed to me that those experiments do not come within any recognized principle of evidence; they are self-serving declarations made up by the defendant; that they are not performed under any conditions which enable us to verify their accuracy or their force; that the only proof which is relevant here is with respect to the prior art, and
3594 that this does not in any way, and can not in any way be said to represent the prior art or any part of it, operations carried on on the 21st day of April, 1917, in machines which were not invented until years after the patent in suit—such things can not by the wildest stretch of counsel's imagination be brought within any part of the prior art, and I shall urge all those objections, in addition to the objections which applied to the specific facts stated as a basis for their testimony.

Mr. Scott: I don't want to consume unnecessary time, but it is a question of the process and of the verity of the statements in the patent in suit. We claim that we have shown that the patent in suit is an absolute misstatement of the facts, which statement of facts we are entitled to attack in 1915 or 1906 or any time while the patent is in existence.

The Court: I have heretofore ruled that I thought experiments, present day experiments, would be proper and admissible for limited purposes. They must have some relation to the prior art, to the condition of things as they were at the time this patent was applied for. How much weight they will be entitled to, or how little will depend upon the conditions under which those experiments have been made. Of course some of them may be such a wide departure from things as they were understood to have been at the time of the application, that they would be entitled to no consideration, and others might approximate*ly* more closely and be entitled to more consideration, and some might duplicate—some might as-
3595 sume to duplicate conditions as they were then at the time that the patent was applied for. But certainly it seems to me that with the accumulation of learning, both from study and from new discoveries, or from mechanical operation, new machinery multiplying operations—it seems to me that if your experiments are to include things of that nature, they would not illustrate very brilliantly the prior art. It is a question of degree, of course.

Take this experiment of the Everson—the Fryer Hill publication. There is a machine which is supposed to give us the Everson operation as described in that publication. It seems to me now, as I said then—of course I am open to argument and open to explanation by counsel—but it would seem to me that one factor entered into that which I do not find in the Everson patent, viz. the agitation, which at least this court originally maintained was a proper part of the

invention in suit. I could not find in the Everson patent that agitation should be resorted to; it does say thoroughly mixed, but you must read the context of the patent, read the full expression, to understand what she was aiming to do and what she meant by that expression. About your other experiments the same might be said; it is all a question of degree. Some of these experiments may go over the line of admissibility, that is likely to happen in any case.

Mr. Garrison: All I was trying to do was to prevent counsel from saying, as the result of this colloquy, that if they brought
3596 certain evidence as to the assays, that the defendants would have met the objection as they understood it, and they did not meet it as I understood it, and I did not want them to be able to claim surprise.

The Court: Oh, yes. I understand from the very beginning, as far as these experiments are concerned, that there is standing objection which was interposed at some time at the very beginning, and which both parties will not lose sight of, when the court makes up its decision.

Mr. Kremer: So there will be no further misunderstanding, we will apply *to* the strict letter of proof in this instance, and insofar as the stipulations, if any, in the Hyde case are concerned, we will place a strict construction upon those stipulations, so that counsel will now be advised; and we will demand a strict order of proof, such as is demanded of us, in the presentation of their case, so that they won't say they are surprised.

Mr. Williams: That is to say, the defendant having about finished its case, and the complainant being about to commence its rebuttal testimony, defendant now announces that every stipulation of record is to receive a strict construction, notwithstanding the fact that a great mass of evidence has been let in without that. I do not accept that.

The Court: No, no; the court understands, and whenever you have any evidence to offer you can bring it up before the court in connection with these stipulations, and the court will read the
3597 stipulations. I have been very liberal with the plaintiff, but these last experiments are clearly outside the stipulation.

Mr. Kremer: What we desire to avoid, if your honor please—I don't want the court to misunderstand—any stipulation we have made we will abide by, but that we want to make an offer of proof and we can not do that without the presence of the witnesses.

I can't make an offer of proof by somebody who is not on the stand, and we are going to have the witnesses here present upon the stand in order that we might make a legal offer. Well, I am not addressing myself to the ruling of the court; the court has ruled and I don't care to comment or discuss that at all; that is past; but as a result of that objection, this condition is made necessary by reason of that objection, demanding the strict letter of proof. There is nothing that we can do under those conditions, except to meet the demand, as your honor will readily understand.

Mr. Garrison: I am not demanding anything.

Mr. Kremer: You demand evidence as to assays which is the same as demanding the evidence of the men who held the samples.

Mr. Williams: We draw a distinction between assays of regular operations of the mill and experiments.

Mr. Kremer: I think we understand each other.

Mr. Scott: I want to know if this is an objection because this is an experimental operation, as distinguished from the regular mill
3598 operation. I don't think the court based its ruling on any such objection as that. I think the court based its ruling on a question of evidence, and not upon this vague objection that this was an operation out of the usual run of the mill operations; if that is the objection that counsel made or that the ruling was upon, I think they should say so here and now, so that the court should rule upon that objection, which I do not conceive the court has ruled upon at all, except in certain instances where similar objections were made—not identical—the court has overruled them.

The Court: Have you heretofore offered experiments like these?

Mr. Scott: Obviously we have had experiments by Mr. Conrads as I remember at the Magna plant, Mr. Thomas Janney at the Arthur plant, in which they used amounts of oil far out of the ordinary, up to 100 pounds per ton and there has been a general objection, it seems to me, on all of this testimony on the ground that we were estopped from trying the case at all.

The Court: Under stipulation as to regular operations, I think.

Mr. Scott: But these were not regular operations in the sense that counsel has stated the matter this morning, that this is not a regular operation, having this large amount of oil as the court so held.

The Court: That is what I say, this one, but the others perhaps went in under this latter.

Mr. Scott: What I want to get is whether the objection he
3599 now is making is upon the ground that this is an experimental and not a regular operation or whether that operation is limited to the proof.

The Court: The court has ruled on the proposition, simply it is one of hearsay. I have not ruled that these experiments were not admissible, but I have pointed out to you all along throughout the record that they may be entitled to very little weight. I cannot sit here and wait while you try an experiment below Salt Lake, and then for them to go down and check that up and see if they can verify it or anything of that sort. I do not think they ought to be put to that trouble, or that the court ought to sit here and wait for them. You have the utmost freedom with all of your experiments in court, as far as that goes.

Mr. Scott: The offer was simply to check up the experiment. Counsel has ruled upon this question, as it has very properly upon the question of evidence produced, that the proof must be more complete. Counsel still say that that is not their objection, but they do not say what their objection is, and give the court an opportunity to rule on it, or give us an opportunity to meet it.

The Court: They too have objected that these experiments under present day conditions are inadmissible, and I think the court has

rather persistently ruled against them. I believe if there are other experiments taken away from Butte in evidence—I don't believe they were specially objected to upon that ground. Of course they may have been.

Mr. Scott: I think with this understanding that we will proceed. I don't recollect whether Mr. Engleman completed everything you wanted of him.

3600 Mr. Williams: Mr. Engleman put in evidence a statement which filled certain gaps in his statement and the only question I would present to him appears on the face of it. You may go on with the next witness.

Dr. SAMUEL P. SADTLER, recalled, testified as follows:

Direct examination.

By Mr. Scott:

Q. 164. I think when you were on the stand before you referred to a certain work describing what was called the cataract machine, and counsel for the plaintiff asked that you supply an additional page for that work. Is this the additional page which was called for?

A. I have here a number of copies of the page just preceding the page containing the illustration, and that was desired because the description of the experiment, or rather the description of the form of apparatus began on that preceding page so that with the page already offered and this page we have the complete story of this apparatus.

Q. 165. I wish you would state the title of the book from which this exhibit which was admitted as exhibit 50 was taken. Just state the name of it and when and where published and the title?

A. The book is entitled "The drying oils, their properties,
3601 compositions and changes, a hand book for lacquer, varnish and color manufacturers, and so forth, by Louis Edgar Andes." Published in Germany, Braunschweig, in 1882.

Q. 166. In your previous testimony, doctor, when you translated the pertinent part of this extra page—the complete translation with the part that is on this page and the other part on the other page with the illustration, was translated and entered into the record.

Mr. Scott: Now, if counsel can consent we will have this added to the exhibit without the formality of offering and further complicating the number of exhibits.

Mr. Williams: This is consented to.

Mr. Scott:

Q. 167. I think when you were on the stand before you referred to several mechanisms described and illustrated in Ure's Dictionary of Arts, manufactures and mines, published in 1860?

A. Yes, sir.

Q. 168. I hand you photograph prints and ask you if those are photographs of the pages of that work that you refer to?

A. I have had photographed the title page and pages 331, 332, 335, 356, and 357, containing illustrations and descriptions of several forms of spitzkastens, and one form of agitating apparatus, involving aeration, when rapidly used, and these are photographs of these pages which were referred to in my previous testimony.

Mr. Scott: I offer the photographic copies from Ure's Dic-
3602 tionary, referred to by the witness, and ask counsel if it will be stipulated that these are copies of the pages referred to?

Mr. Williams: It is so stipulated, subject to possible correction on further examination, but I guess not any.

Pages admitted in evidence and marked Defendant's Exhibit 215.

Mr. Scott:

Q. 169. Were you present in court, Dr. Sadtler, when Mr. Dosenbach performed two experiments illustrative of the Everson patent, one in the Fryer Hill machine and one in the cataract machine?

A. I was.

Q. 170. I am assuming that you will be unable to remember all of the facts and details and I will refer you to the description of the details as given by him in the typewritten transcript and ask you to compare what he did with what is described in the Everson patent. (Page 1212 of the statement of facts.)

A. This was an ore which was crushed to 40 mesh, as stated here and a portion of this ore having been taken and another portion given to representatives of the plaintiff. 51 gms. of oil were taken, these 51 gms. of oil, taking into account the specific gravity of the oil, figures out exactly 17 per cent of oil relative to the ore, which was the proportion cited by Everson in her description of the operation using paraffin oil. In that particular case an oil of a certain gravity was taken and a calculation readily allowed the ascer-
3603 taining of the relative weight of that oil per unit of ore. Therefore, it was 17 per cent. 1250 cc. of water having a temperature of 42° C. were used. 2.4 cc. of sulphuric acid added to 50 cc. of hot water were added after the machine was started. The rotation was between 1400 and 1500 revolutions per minute, as experimentally tested. After rotating the revolving blades there was obtained a mineral froth of the copper sulphide mineral and air bubbles, and this amounted to something over an inch in thickness, from an inch to an inch and a quarter. The difference in appearance between this froth, in color, and the tailings was quite noticeable. That having been done, a sample of the concentrate was obtained—that having been done, the Fryer Hill publication was followed still farther in that the semicircular doors which previously had been hanging down during the time of the rotation, acting thereby as baffles during the rotation and assisting in the entraining of air, these semicircular doors were raised so that they came up just under the layer of the floating froth. I examined them at the time and noticed the position of the doors and they were in position after being raised and the froth collected upon them. Then by lowering the

jar with its contents, that is the liquid under the froth, it was possible to hang or to leave these doors supporting the froth and separated in that way from the other portions of the liquid. In the Fryer Hill publication we have the description of these parts of the drawing and it states that the water will drain through the fine openings in these semi-circular doors leaving the floating mineral upon
3604 them. Samples were taken of that concentrate by washing the material off of these supporting doors, after having removed the other portion of the liquid below. I consider that this was a carrying out of the Everson process in principle. I consider it was a very careful following of the Fryer Hill description also in which a form of apparatus was described which had been utilized for the illustration of the Everson process.

Q. 171. Referring to the Everson patent and particularly to the procedure as defined in the paragraph beginning at line 93, page 2 of the patent, page 608 of the Hyde record, I would ask you what, if any, directions you have for such agitation of the mass of pulp and oil as took place in the Fryer Hill machine?

A. "In the use of petroleum, or a liquid constituent thereof, like paraffin oil, the condition of the concentrated mass is more liquid than when a vegetable or an animal oil or a fatty constituent thereof is used, and a somewhat different means or method should be employed for removing the sand. In practice, the concentrate, after thorough agitation of the mass and detachment of the sand, will in this case be perfectly removed by means of a constant overflow of water, from a washing out vessel, by which overflow the concentrate will be floated off." We have there of course the thorough agitation as the first step, the detachment of the sand is the second step and the removal of the concentrate as the third step. This is all illustrated in this procedure using the Fryer Hill form of apparatus.

3605 Q. 172. Now, doctor, will you turn for a minute to the patent in suit, No. 835,120, and tell us what language you find there regarding the character and degree of agitation.

A. In the patent in suit we have the statement with regard to agitation as follows, on page 1, beginning with line 82: "The mixture is warmed say to 30° or 40° C., and is briskly agitated in a cone mixer or the like as in the process previously cited, for about two and a half to ten minutes, until the oleic acid has been brought into efficient contact with all the mineral particles in the pulp." Then we have a description of what results from that agitation.

Q. 173. What was that process previously cited that is referred to in the passage you have just quoted?

A. I assume that it refers to the Cattermole processes which were cited in the earlier parts of this same patent.

Q. 174. Can you state whether any especially violent agitation was a characteristic of the Cattermole process.

A. It was.

Q. 175. Now, did you see the second experiment performed by Mr. Dosenbach as representing the procedure of the Everson patent

in which experiment he used what was called the cataract machine described in the German book by Andes?

A. Yes, I also witnessed that.

Q. 176. I will refer you to the transcript for the details.

3606 A. Found on page 1217 of the transcript. 300 gms. of Utah Copper retreatment classifier overflow, containing approximately 7.9 per cent copper, 5.36 per cent iron and 77 per cent insoluble, was taken as the ore. To this ore was added 51 gms. of petroleum distillate. This was also calculated to make 17 per cent of oil reckoned on the ore, and it was thereafter mixed until a homogeneous mass was formed. This mixture, following the Everson process, was made before the thinning out of the pulp with water. This oiled ore was placed into the cylinder of the machine and 1250 cc. of water added at a temperature of 40° C. The machine was then started up and 2.4 cc. sulphuric acid, and 50 cc. of hot water was added, and the agitation continued for a period of two and one-half minutes. Upon stopping agitation a mineral froth formed above the semi-circular doors—that "above the doors" was not necessary there—being about one and one-eighth inches in thickness. After allowing the gangue material or tailings to settle to the bottom of the cylinder so that the solution was comparatively clear between the froth and the gangue——

Mr. Scott: You are reading the wrong description.

A. I read the description that followed after that.

Mr. Scott: The ingredients are the same but the apparatus was different. I will find it for you.

Mr. Williams: What you have just read is the alleged Fryer Hill experiment.

A. The semi-circular doors identify that.

3607 Mr. Scott: Page 1218 I think it begins.

A. That is just what I was reading, 1218. The description of the apparatus begins on page 1220 and continues on page 1221. The oil and the ore were thoroughly mixed as before. And the description of the apparatus in detail is on page 1223. In the experiment just completed, following out the Everson patent in the so-called Cataract machine—that is 1223—"I used 200 gms. of Utah copper retreatment classifier overflow containing about 6.18 per cent copper, 6.69 per cent iron, and 76.2 per cent insoluble. I added to this 200 gms. of ore, 34 gms. of Texas petroleum distillate and thoroughly mixed the two to form a homogeneous mass." That 34 gms. is again 17 per cent on the ore taken. "I thoroughly mixed the two to form a homogeneous mass." The mixture was made as in the other case before thinning out with water. "Having placed this oiled ore into the machine, I added 1250 cc. of water at a temperature of 30° C. I next started the machine and directly after starting the agitator I added 50 cc. of hot water containing 1.6 cc. of concentrated sulphuric acid. The agitation was continued for two minutes and a half at about 1720 revolutions per minute. The result upon stopping the agitator was that a very highly mineralized froth appeared on the surface of the pulp." The sample was removed and

furnished to the complainants for examination. I witnessed that operation and noticed the appearance of the froth at the time.

Q. 177. And what was the result of your observation of the froth and the experiment generally?

3608 A. It was a very dark, mineralized froth, and as stated was approximately one and one-quarter inches or more in height, being rather more than in the preceding experiment with the Fryer Hill apparatus.

Q. 178. With the exception of the difference in the apparatus, did you notice any other differences in the procedure and in the ingredients used between this cataract machine described and the one in the Fryer Hill machine?

A. There was no difference in the principle. There was a difference in the amount of ore that was used and a difference in the amount of oil used. The ratio was precisely 17 per cent oil to the amount of ore taken. It was the same ore in the two cases and the agitation had the same effect, in the cataract machine as it had in the other form of apparatus with the semi-circular doors, the agitation resulting in the entraining of air and the result of that in turn was the formation and—formation of an aerated froth which was highly mineralized, which it showed on coming to rest.

Q. 179. Are you familiar, doctor, with the Froment Italian and British patents?

A. I have read them carefully.

Q. 180. Will you explain the process set forth, especially with regard to the Froment Italian patent.

The Court: Any difference.

Mr. Scott: Just slight difference which the doctor will refer to.

A. The Froment Italian patent I will first notice.

The Court:

Q. 181. These are in the Hyde suit?

3609 Mr. Scott: This is the Hyde case, yes.
The Court: Proceed.

A. The Froment Italian patent has as its title in the translation which I give it, "A Process for Enriching the Sulphide Ores of Copper, Lead, and Blend by gases combined with fatty bodies." This differs very slightly from the English translation which was submitted in the Miami record.

Q. 182. In the Hyde record?

A. In the Hyde record also previously. I think the translation I gave it is a little better because it does not say "Sulphide and copper ores" in the original French, but it says, "The Sulphide Ores of Copper" because the word "sulphures" there is used as an adjective and it is the sulphide ores of copper. Therefore, I prefer the translation as given: "A process for enriching the sulphide ores of copper, lead and blend by gases combined with fatty bodies." There is no word in this title, the original French of the Italian patent, or

in the English translation which was given in the Hyde record, there is no word offered of its being a modification of any previously known oil process of ore concentration. That does not appear at all in the Italian patent. I will refer to that again. Now, we take up next in the Italian patent the phenomena. Mr. Froment says: "The following phenomena studied by the inventor have served as the basis of the process which forms the subject of this invention." These phenomena are four in number and as stated I would like to read them consecutively so that we can consider them together:

3610 "First, when the natural sulphides reduced to fine powder are moistened by a fatty substance they have a tendency to unite in spherules and to float upon the surface of the water.

"2. This tendency is simply retarded by the specific weight, and opposed by the gangue which imprisons the moistened sulphides in its pulverulent mass.

"3. If a gas of any kind is generated in the mass, the bubbles of this gas become covered with an envelope of sulphides and thus rise readily to the surface of the liquid where they form a kind of metallic magma.

"4. The formation of these metallic spherules is singularly active if the gas is in a nascent state."

Now, these are the four phenomena stated together as a basis of the Froment invention. This represented his invention which he considered to have been original. It seems to me that to understand Froment's discovery these phenomena must be considered as connected and not analyzed singly, as only thus can we arrive at an understanding of his meaning—a proper understanding of his meaning. For instance, the reference to "spherules" in the first paragraph cannot be understood until after we have read the third paragraph when this very expressive term becomes understood. In previous discussion of this matter it has been attempted at times to give two entirely different meanings to the word "spherules," contending that it meant one thing in one paragraph and another thing in another paragraph. I think I can show that is not a proper interpretation of Froment's meaning. The mere moistening of

3611 the fine powdered ore with a fatty substance could have no effect to produce spherules that would float on the surface of the water whether we add much or little fatty oil. We would get the pasty mass of Haynes or the first Everson example, and the addition of water to this while allowing for the washing out of the gangue would not cause the production of spherules that would float upon the surface of the water. If there was an occasional little appearance of oil in the water this would not be properly described as "spherules" in the meaning as given here. If, however, we read the statement of the third paragraph and remember what is said in the first paragraph about the spherules floating upon the water, the phenomena are readily intelligible. The generation of gas in a mixture of ore, oil and water under the conditions given, and immediately after in his example also will have the result described in the third paragraph, namely: "The bubbles of this gas become covered with an envelope of sulphides and thus rise readily to the sur-

face of the liquid where they form a kind of metallic magma." We can now understand the fourth paragraph immediately following: "The formation of these metallic spherules is singularly active if the gas is in a nascent state." If, "spherules" were to be taken apart and considered as formed under the conditions mentioned simply as there in the first paragraph, we couldn't have any meaning to this fourth paragraph. The meaning of the fourth paragraph is only
possible when we have the full connection with several phe-
3612 nomena, the mixing of the sulphide ore with the fatty substance, the generation of the gas in this mass and then the presence of water so that we shall have a liquid in which something can rise, and then we have stated that "the bubbles of gas, covered with an envelope of sulphides rise to the surface of the liquid, where they form a kind of metallic magma." Now, on the top of the next page in this Froment Italian patent we have still more light thrown upon this matter. We have this statement:

"Accordingly the rapidity of the formation of the spherules and their ascension is in direct ratio to the quantity of gas produced in a given time."

Q. 183. Just where is that, doctor?

A. I think it immediately follows, just before example 1.

Mr. Williams: The latter part of page 910 of the Hyde record.

Just before example 1. There we have so clearly expressed the condition of the formation of the spherules to be dependent upon the generation of the gas and the greater or less rapidity with which they will rise are based upon that, that it is utterly ridiculous to talk about two kinds of spherules referred to by Froment. The spherules referred to by Froment are only a development after gas has been generated. Now, we come to the third paragraph, especially to this phenomenon again of the magma. What is it that is there stated to form a kind of metallic magma? The answer to that is: the bub-
bles of gas covered with an envelop of sulphides which rise
3613 to the surface of the liquid. These bubbles of sulphide-coated gas are obviously referred to in the fourth paragraph, where their formation when the gas is in the nascent state is spoken of, and they are called metallic spherules, from their round form as they show in the coherent froth or magma. This clear meaning is, however, confirmed in the illustrative example which is given immediately following. We have the statement: "The metallic spherules, pressed one against the other, will become grouped in a magma, clearly separated from the remainder of the liquid."

The Witness: In illustrating the example we have there the statement "the metallic spherules pressed one against the other, will become grouped in a magma clearly separated from the remainder of the liquid." Now, we have the definition of magma in Froment's own language, "The metallic spherules, pressed one against the other," and we are very familiar with that appearance by looking at these mineral-coated froths, looking down at them from on top—"and the magma clearly separated from the remainder of the liquid."

This is what Froment meant by a magma, clearly expressed in his own words and defined for us, no matter what other definitions have been found for the term in metallurgical usage or in smelting practice.

Of course it is entirely possible to find many illustrations of magma, and the word magma has been used in a great many connections and in a great many lines of practice, but we are tied up here
3614 by Froment's own explanation and description of what he means. It is the predecessor of the fixed, coherent, armor-coated froth of the patent in suit. It looks like it, and is similarly constituted, and is produced by the same steps, namely the agitation of a sulphide—containing ore with oil and sufficient excess of water to entrain air, and thus cause the formation of air bubbles which, as Fromen says in the third paragraph—I should say gas bubbles, because it must be made broader than air bubbles—"gives rise to the formation of gas bubbles" which Froment says become covered with an envelope of sulphides and rise rapidly to the surface of the liquid, where they form a kind of metallic magma. The result is the same froth whether we take it as a number of "metallic spherules pressed one against the other," using what he has called or considered as grouped into "a magma clearly separated from the remainder of the liquid," or whether we talk about "coherent, armor-coated froth."

Now, these are my conclusions, reached after a very careful study of Froment's language, analyzing every word of it and trying at the same time to bring the several parts of his description together, and they also are based upon my observation of a great many highly coated froths which have been produced in numerous experiments here, and I would like particularly to call attention to this description of Froment, in connection with the pictures and photographs which have been put in evidence, particularly if we look only at the photograph in which the picture is taken looking downward.
3615 The appearance of the armor-coated froth is absolutely the appearance of the "metallic spherules pressed closely together and forming a magma," as described by Froment.

I would also like to say that this description of Froment's, of his mass of metallic spherules forming a magma, and the appearance of the metallic-coated froths as seen in the photograph, exactly illustrates the definition of the froth which was given in this testimony by Professor Bancroft. Professor Bancroft's definition of a froth—and it is of record—was as follows: "Froth is a closely packed mass of bubbles having a honey-comb or cellular structure, the walls of the cells being liquid films, and the individual cells containing air or other gases." That is broad enough to include air and other gases or mixtures. And then add to that definition of a froth the result which ensues when we have the froth generated in the presence of an oil, and the selective action whereby the mineral sulphides concentrate in the film inclosing the bubbles.

Then we pass from the froth, as a broad expression, to the special mineral-charged froth of the patent in suit, and of these other illus-

trations which we have considered. I have also in my previous testimony referred to the language of the two patents of 1910, taken out by Theodore Jesse Hoover and Minerals Separation Limited in one case, and by Edward H. Nutter and Minerals Separation in another case, in which they cite the English patent No. 12,778 of
3616 1902, which is the English patent of Froment, and in which English patent these descriptions and these statements of the phenomena, and this description of the metallic spherules and of the magma, is exactly the same as it is in this Italian patent, translated. They refer to the result of the Froment patent as showing the process of carrying oiled particles to the surface, in the form of a froth or especially as a gaseous froth, and they bracket this British Froment patent with the English patent corresponding to the United States patent No. 835,120, as being descriptions of well-known flotation processes.

I had another reference here, but I can't find it.

I now pass to the features of the Froment process as shown in the example which immediately follows the statement of the four phenomena. We have, following that statement of the phenomena an example of an experiment in a test tube, and I will take that up.

First, the components of his mixture, he states here are ten grams of sulphide copper ore with its gangue, 1 gram of limestone, reduced to powder, and 30 drops of water, and a few drops of sulphuric acid, and a thin layer of ordinary oil. In this mixture as thus stated, the ten grams of powdered ore furnished us the sulphide particles and gangue which as a result of the process are to be separated. The one gram of limestone is to react with the sulphuric acid and thus to generate carbonic acid gas, which furnishes a part of the bubble by the gas, which is the basis for the rising spherules referred to in the last paragraph of the example. The 30 grams of water give us the floating pulp, and is the liquid on the surface of which the
3617 metallic spherules that are grouped in a magma clearly separated from the remainder of the liquid are supposed to float, and the few drops of sulphuric acid liberate some carbonic acid gas. The few drops of sulphuric acid—we might take two or three—being insufficient to decompose the whole of the one gram of limestone contained.

In that connection, a calculation can be made as to how much of the limestone would be decomposed by the few drops of sulphuric acid. Dr. Chandler has stated in the Hyde record, volume 2, page 647, that 1 cc. of sulphuric acid amounts to from 26 to 32 drops, and other experiments have been carried out and have given the statement that 40 drops constitute 1 cc. Being very liberal with that, and taking the figure of Dr. Chandler, we can readily calculate how much that 2 drops of sulphuric acid will furnish, therefore, in weight; of course, knowing the weight of 1 cc. of sulphuric acid—the sulphuric acid referred to is the strong sulphuric acid, and 1 cc. of that weighs 1.84 grams, because that is the specific gravity of strong sulphuric acid. Therefore, if we take 2 drops, we would have perhaps only 1/15 or 1/20 of that 1.84 grams, as the active sulphuric acid which is to decompose the limestone. Now, pursuing the calcu-

lation, 1 cc. of sulphuric acid, weighing 1.84 grams, in decomposing limestone will produce .8 of a gram of carbon dioxide, which
3618 amounts to .4 of a litre. Those figures can be found in Dr. Liebmann's testimony—that is, the calculation may be found in Dr. Liebmann's testimony; I can not give you the page for the moment, but I will give it later. Dr. Liebmann has given us that calculation exactly, that 1 cc. of sulphuric acid produces .8 of a gram of carbon dioxide, amounting to .4 of a litre. Now, 2 drops thereof, the 1/15 or 1/20, according as we regard the number of drops, to the cubic centimeter of sulphuric acid, would produce, therefore, about .04 of a gram of carbon dioxide, which would be .02 of a litre, or 20 cc. of carbon dioxide, which would be produced—and I will be liberal with that and make it 30 cc. of carbon dioxide which would be produced by using 2 drops of sulphuric acid, acting upon 1 gram of limestone present in this mixture of Froment. Therefore we get a partial decomposition, with a possibility, using the larger figure, of 30 cc. of carbonic acid gas liberated in this test tube experiment, which is here described by Froment.

The remaining element of the mixture is the oil. The words used by Froment are, "or a thin layer of ordinary oil." This does not state the amount by weight or measure, and does not give a definite description of the kind or amount of oil, but we can make a guess at how much he meant and what was the character of the oil. First, what did Froment mean by an ordinary oil? Fortunately, he tells us in this same Italian patent which we are considering, in the claim
in the Italian patent, according to his expression, "combined
3619 with an oily fat body, and not with an oily body derived from bitumens, tar, naptha, etc." This is perfectly clear as a definition. He does not use petroleum or any derivative of it, or any residuum of petroleum, nor tar nor any residuum of residual of tar. What he did use was a so-called fatty oil, or it is sometimes called, to distinguish it from the essential oils or volatile oils, a fixed oil. However, Froment goes still further in making his meaning definite. In the original French used in the Italian patent he says, "un corps gras oleifiant," which, literally translated, would be a fatty body of the oleifine type. What this means is known to every chemist. The term olefine is taken from the well-known olefiant gas, (or oil-forming gas), known also to chemists as ethylene gas. The name olefine, or as it is in French, "olefiant," is now applied to all the derivatives of this olefiant gas, and in this series we have for example the fatty body olein, and the free fatty acid, oleic acid, obtained from the decomposition of olein. On the other hand we have stearin, and a fatty acid, stearic acid derived from it which do not belong to this olefine series.

Now, of this class of oils we have a typical example in the vegetable kingdom of an olein, viz., olive oil. This exactly fills this description of a fatty body of the olein type, and at the same time it is the ordinary oil of Italy, in daily use as food, and sometimes as an illuminant. I am satisfied that in view of the limitations imposed in the claims of this patent, that wherever in the Italian patent ordinary oil is referred to he meant olive oil. It certainly could

3620 not mean petroleum residuum, as that is absolutely excluded by the wording of the patent claim.

I want to go still further on that exclusion of petroleum. If you take the original French of the claim, he has three words, ("Bitumes, goudron, napthe, etc.") and which have been translated, bitumen, tar and naphtha. It is in regard to the last that I want to say a word. The word naphtha is generally applied now to a fraction of petroleum, but in the past it was not so applied either in this country or abroad. When the oil development first began in Western Pennsylvania in 1859, the oil occurrences were always referred to as naptha springs, and the crude product was referred to as naptha. That is not, at the present time observed as a designation in the English language, and to illustrate that, I will read from Bacon's "American Petroleum Industry," which is a new and very complete book just published, and in the rear of this book we have a glossary of terms with the meanings, and I take the word naphtha, and I find as follows, in regard to it: "This term, which was formerly applied to any fluid, and volatile variety of bitumen, is now generally applied merely to those petroleum fractions which boil below 280° F." That is, in American usage, it is no longer applied to a crude oil, but is applied specifically now to this light fraction; but in the foreign usage it is still applied to crude petroleum, and I have here a French technological dictionary, the title of which is "Tolhausen Dictionaire Technologique." This is a splendid work, which

3621 I have known for years, and in this volume we have the French word first, and then the German and then the English, and if I turn to the word "naphthe," which is found in the French patent, we find as a synonym for that, "huile de Petrole," or petroleum oil, or simply petrole. Then, as the German equivalent of the word napthe, "erd-oel, Stein oel," and as the English equivalent, naphtha, rock-oil, petroleum.

I really believe, therefore, that we are perfectly justified in translating Froment's French language in an accurate way, and if we translate it in an accurate way we will see that that portion of the sentence inclosed in the brackets absolutely shows that, not only bitumens of all kinds, tar of all kinds, but also petroleums are named; and if we take with that the other showing in the claim of the patent, that he particularly prescribed a fatty body of olefine type, I think Froment has limited the kind of oil very distinctly for our benefit.

Now, we come to the quantity of oil. As before said the expression "a thin layer of oil" is not very definite. Dr. Liebmann, in the Miami case, in testifying stated that using olive oil, he found the amount necessary for a thin layer amounted to 12.5 to 15%, reckoned on the weight of the ore. If we take 10 grams, this would amount to 1.25 grams, or 1.5 grams respectively, of oil.

There is other testimony on this matter, however, in the Hyde record, volume 2, page 308, where William Henry Ballantyne, who testified, said as follows: "I frequently tried the Froment

3622 process in a test tube, and I found that a thin layer of oil amounts to not less than about 5% of the weight of the ore."

I made a number of tests of my own to get a thin layer of oil, using olive oil, and I found that, according to the temperature of the water mixture, I was able to get a layer of oil which not only was relatively a distinct layer—more than a thin layer, looked at from the side—but I took it that the point which ought to decide the matter as to a layer of oil was looking at it from above, in regard to touching the circumference of the glass or test tube, and getting a layer of oil which completely touched the glass all around the edge, I was able to get a layer with a little less than 1 cc. of olive oil when I used the lowest temperature, which was 25° C., and when I used a temperature of about 40° C., which is not very warm, I found that about .3 of a cc. of olive oil completely touched the sides of the glass test tube, and therefore made a layer of oil which was a complete layer covering the whole of the water underneath. Therefore I assume that 1 cc. of olive oil would be quite sufficient, even with a lower temperature, to answer the description of Froment as to the amount necessary to be used to form a thin layer of oil. Now, with the specific gravity of olive oil, which is about .9, that would give us 9%, reckoned on the weight of the ore; so I would be satisfied to call it 9%, which is rather less than was stated by Dr. Liebmann, and is rather more than was stated by Mr. Ballantyne, and 9% is quite sufficient to illustrate the experiment with.

We go now to the consideration of the steps of agitation.
3623 This is referred to in the Froment Italian patent in the test tube example and says "and the mixture then agitated for a second." The English patent, referring to the step, says "then agitated for a brief space."

Under these circumstances we may assume that the "second" is not to be measured to the minute fraction, but is an approximate measure for a brief agitation. I take it that the words "agitation for a second" is a figure of speech, meaning a very brief agitation.

As the experiment given by Froment in his example is carried out in a test tube, the agitation is most readily effective by closing the test tube containing the mixture with the thumb and shaking it momentarily, approximately a second or two. Now, the results.

The result of this agitation I find as it is stated to be, that the copper pyrite, that is, the metallic mineral, will instantly rise to the top of the liquid. That is the expression "will instantly rise to the top of the liquid."

Now, the appearance of this mineral which thus rises through the liquid to the top is then stated. It is not sufficient for us to understand that the copper pyrite rises to the top of the liquid; its appearance, and conditions by which it exists at the top of the liquid are clearly stated. "The metallic spherules, pressed against one another, will become grouped in a magma, clearly separated from the remainder of the liquid," and then of course the production of the gaseous froth, as a result of agitation. This froth, the gaseous
froth produced, is unquestionably produced directly by the
3624 agitation; the agitation is the direct cause of its production.

A further statement of the result which follows immediately after is, that the small quantity of gangue, mechanically en-

trapped, gradually falls from the sulphides and the sulphides remain in a state of almost complete purity. Such is the principle.

Now, we have in this section, which gives an example of the working of the test tube experiment, a caution to the inexperienced in chemical manipulation; Froment says, "if the limestone is in excess, or readily attackable, the rapidity of the separation is so great that the copper pyrite is forcibly ejected from the vessel. Therefore, a correct proportion has to be given for a given ore and a given limestone." Now, it seems to me that that, taken together with the mention of the proportions and of the amounts of the different ingredients, is all that is necessary to enable one to entirely avoid a good deal of what looks to be *to be* simply illustrative of inexperienced manipulation.

That a test tube should be shaken and the whole of the contents thrown violently out and over against the wall is not a necessary result if he pay attention to what Froment has stated. It might happen occasionally, but I am satisfied that, if we take the statements made here, the decomposition of the limestone is going to be such as to instantly throw out the contents of the test tube.

In some of the previous experiments that I have read in connection with the testimony in this action, illustrating Froment, the
3625 amount of acid was distinctly taken fully equal to the amount of limestone. Froment does not indicate what that would do, or that we should take 1 gram of limestone and 1 gram of sulphuric acid. If he had meant to say so, he would have said so, and therefore, if we take his language and make our translation accurate, we can see what the minimum decomposition of the limestone would be, which limestone is here 10% of the ore. That amount is absolutely unnecessary, and it is not contemplated except as an accident, and as to the accident, of course, he has given a caution.

There is one other statement that we need to notice before going on to the claims of the patent; in connection with example No. 2 of Froment's Italian patent, which comes just before the claim. The statement is as follows: "There are several distinct but connected operations in the practical working of the process; the formation of the spherules and their separation from the gangue, then separation of the concentrate and the oil, and recovery of this latter for a reentrance into the circuit of operations. The products of the concentration form oil cakes." The English patent simply says, "form cakes." I simply conclude that Froment at the time thought that there would be a possibility of his pressing his concentrate and recovering the oil. That is another matter, however, and I have not taken that up, because it does not illustrate the principle of the froth formation; the froth formation is entirely irrespective of whether he recovered the oil or did not recover the oil, and
3626 therefore I leave that for what it is worth.

The first of these operations, the formation of the spherules or gas-bubbles coated with a film of oil carrying metallic sulphides, and their separation from the gangue by reason of their rising to

the surface of the liquid, where they form a dense metal-coated froth or magma, as Froment has called it, has been discussed already.

The other two relate to the concentrate already existing apart in the froth on the surface of the liquid. How these two latter steps are carried out he does not state here, and for light on this subject or his later development we have to turn to the Froment description, a document which was not published, and is not essential to the understanding of the principle.

I now come to the claim of the patent. I have already referred to it somewhat in speaking of the nature of the oil. However, as it is short, it will be well to give it in full.

"I therefore claim, as being my exclusive and entire property, a process consisting in enriching sulphide and other ores, graphiteous ores and their derivatives, sulphide earths, or others, by means of gases, whichever they may be, combined with a fatty body of the olefine type, and not with an oily body derived from bitumens, tar, petroleum, etc., and whatever may be the apparatus in which the process could be applied."

Before commenting upon this claim, which is very broad, let us compare it with the claim of the corresponding English
3627 Froment patent, No. 12778, of 1902. The wording there is as follows, found in the Hyde record, page 787.

"The herein described process for the concentration of metalliferous ores and earths, which consists in commingling the finely powdered ore or earth with water, and adding a suitable oil, and then liberating a gas in the mixture, substantially as described and for the purpose specified."

This is condensed, but it is condensed at the expense of clearness of statement, and involves the omission of the clear intent of certain features of the invention, viz., the defining of the kind of oil to be used. In several points, also, I consider that the wording of the English patent claim is less explicit; there is, in addition to this matter of the character of the oil—for instance, the Italian claim is for a process to enrich sulphide and other ores, graphiteous ores and their derivatives, sulphide earths, or others." While the English claim is for a process "for the concentration of metalliferous ores and earths," without qualification. It is broader, obviously, but it is less informing and less definite.

(Recess.)

The Witness: I was speaking of the points of difference between the claim of the English patent and the Italian Froment patent. I stated that the English patent claim was distinctly less explicit in several respects. This view is not solely my own, but is shared by Dr. Liebmann, one of the experts who testified on one of the former trials in connection with this process in Patent 835,120, and I
3628 find in the Hyde record, Volume 2, page 460, Dr. Liebmann's expression about this same thing as follows: "The Italian specification precedes the English one by a short time, and the English is clearly a translation of the Italian document, with such light alterations as a translator who is a British patent agent

would make. There are some mistakes in the British document, which cloud the true meaning of the original, to which I shall refer later." Dr. Liebmann pointed out also, as I have done, some distinct points of difference. In my mind the most important point of difference by far is the absolute silence in the claim of the English patent as to the character of the oil which Froment desired to use. The term "suitable oil" is utterly inadequate in view of what appears in the Italian patent, in which Froment quite distinctly and specifically limited the kind of oil which he had desired to use.

On the other hand, the English claim indicates the general method of the operation described better than the Italian claim. The English claim, for instance, says: "It consists in mixing the finely powdered ore or earth with water, adding a suitable oil, and then liberating a gas in the mixture, substantially as described and for the purpose specified," while the Italian claim does not give these steps, but merely claims "by the means of gases, whichever they may be, combined, with an oily body of olefiant type." The Italian patent claim therefore does not tell us how the co-operation of the
3629 gas and the oil is to be effected; but while that is wanting in the Italian claim, the information contained in the specification and example of the Italian patent are perfectly adequate to supply that information; the information is quite complete if we take it from the specification, including the phenomena as stated, and the example.

Now, we come to the nature of the gas which forms the spherules in Froment in the example given in his Italian and British patents. In the Froment Italian and British patents, the test tube examples given quotes 1 gram of limestone to 10 grams of ore and a few drops of sulphuric acid. I have already shown that this amount of sulphuric acid is insufficient to decompose the calcium carbonate of the limestone. The amount mentioned in the patent of 10% of limestone relative to the ore was too much, and that is also intimated by Froment in the same paragraph, where he says "a correct proportion has to be found for a given ore and a given limestone," which shows us that he did not wish to intimate that the reaction required uniformly the same amount of limestone; and later, when he comes to furnish his description, he goes into that subject much more fully, and gives the amount of limestone relative to the amount of ore, which is very much less than is here stated in the example.

In the Froment instructions to which I just referred 1%, or in difficult cases a maximum of 2% of limestone is stated to be the correct amount, as against the 10% which is to be given in the example. The sulphuric acid added in the second stage of
3630 the operation described in Froment's instruction is calculated to exactly correspond in that case in weight with the calcium carbonate, which is essential to effect the complete decomposition.

Coming back, however, to the test tube experiment of the Froment patent, which is the nature of the gas which inflates the metallic spherules which rise to the surface on agitation?

It has been assumed that it is essentially, if not entirely, carbonic acid gas. I think a little reflection will show that this can not be

the case. We start with a test tube containing 10 grams of ore, one gram of limestone, 30 grams of water, a thin layer of oil, and a few drops of sulphuric acid, insufficient in amount to decompose the amount of limestone present. The rest of the open space in the test tube is of course filled with air. We close the test tube and shake up vigorously for a second. The volume of carbonic acid gas liberated, corresponding to the partial decomposition of the limestone by the few drops of sulphuric acid, is small. Remember, now, that under normal atmospheric pressure, one volume of water will retain, dissolved, its own volume of carbonic acid gas, so that it is only the excess over this volume that is free to escape and mix with the air which is being entrained by agitation. The mixed gases which form the froth or magna of metallic spherules, it is plain, must be predominantly air, with a relatively smaller amount of carbonic acid gas, which will inflate the air bubbles, or gas bubbles, we will call them. The mixture of gases, therefore, which form
the froth or magma, it is plain, will be a mixture of carbon
3631 dioxide and air, and predominantly air, with a relatively smaller amount of carbonic acid gas.

Dr. Liebmann, a former witness, has testified in the Hyde record on this matter in volume 2 of the Hyde record, page 557, as follows:

"I pressed the lower end of the thumb on the test tube, and shook first for two seconds, what one might call violently. Then I made an observation, and after that shook again for 6 or 8 seconds. The amount of carbonic acid which could have been evolved was so small that it would have been dissolved in the water which was present. It requires over 7 cc. of water for the solution. From the experimental evidence and from my experience, I have grave doubts whether carbonic acid would evolve at all."

I would not go quite that far. I think carbonic acid is evolved as far as my experiments in the test tube have shown, but I will agree with Dr. Liebmann that the amount of free carbonic acid gas, which is residual, after the reaction and which can mix with the air already contained in the vacant space in the tube, is small in amount, and therefore the conclusion is readily drawn that we would have a mixture of carbonic acid and air, in which the air is certainly two-thirds or three-quarters of the mixture. That would make it accord with the proportion of the mixtures which have been produced under the processes of the patent in suit when they were operating with ores relatively rich—containing say five to six per
cent of calcite. Dr. Liebmann has testified in that connec-
3632 tion as to the analysis of the mixture of gases resulting from the operation with the San Francisco del Oro ores in Wales, where he found as a composition of the gases inflating the froth produced by the operation of the patent in suit, 77½% of air and 22½% of carbon dioxide. I do not believe that if we carry out the test tube experiment of Froment, using the proportions that have here been stated, that we will have as the composition of the gas mixture anything very different from what is there stated to be the composition of the gas mixture inflating the froth produced by the patent in suit. It must be remembered that we also have in the

Froment Italian patent the claim, "by means of gases, whichever they may be." And we must remember also that the patent in suit, No. 835,120, says, page 1, lines 91 to 94: "A froth or scum which has derived its power of flotation mainly from the inclusion of air bubbles introduced into the mass by agitation."

"A froth or scum which has derived its power of flotation—" I didn't quote it correctly before—"A froth or scum which has derived its power of flotation mainly from the inclusion of air bubbles introduced into the mass by agitation." We find, therefore, that a gaseous mixture is possible and is allowable by the language of these two patents, in either the case of the Froment or the patent 835,120. The Froment description which became public later need not be discussed in the same way that we have discussed the two patents in which Froment made known to the world his discovery
3633 and clearly enunciated his understanding of the principles therein involved, and made his broad claims. The description, with accompanying drawings shows a two-step process instead of a single step process as given in the example of the patent, Italian and British. We have in the Froment description——

Mr. Scott: Page 730, volume 3, of the Hyde record, that is the translation of it.

A. 730 of the Hyde record, volume 3; the description with accompanying drawings shows a two-step process instead of the single step process given in the example of the patent. We have a centrifugal mixer for the ore pulp, limestone and oil, in which there is an energetic agitation which, from the construction of the stirring devices, entrains air and forms an aerated froth. The stirring devices are shown there in the dotted lines which are to revolve in "a," centrifugal mixing device, by the revolution of this stirring device we have the same vortex form of motion generated, and the entraining of air with the formation of an aerated froth. This, however, is discharged without being allowed to separate, discharged into a vat with leaden coil for the introduction of sulphuric acid and steam, and with a horizontal rake to be slowly revolved after the introduction of the sulphuric acid, and thus gives a supplementary gas-bubble development for the purpose of raising additional mineral not already in the froth formed at first. The only radical difference is that the sulphuric acid comes into the operation in the so-called coil
3634 vat. In the test tube experiment, it is all done momentarily and in the reaction of the sulphuric acid in the test-tube experiment we of course have an actual reaction of the sulphuric acid on calcite; but the brisk agitation gives us the shaking up of a large volume of air in the test tube with the watery pulp and oil globules and the entraining of the air with the incidental amount of carbon dioxide is accomplished in this way. The accomplishment of the result is rather different in the process described in the Froment description. A Froment machine built upon the description and built to operate as here figured I have seen operated repeatedly and I have seen results obtained from the same which gave an excellent froth, as a result of the first operation, supplemented by a small additional

amount of froth by the operation of the sulphuric acid acting on the limestone in the water.

Q. 184. Do you wish to illustrate the Froment patent?

A. I would like to have the test tube experiment shown. (Test No. 37.)

Mr. Scott: Do you want a sample, Mr. Williams?

The Witness: This is Butte & Superior ore we are talking about in this case, 10 gms. Butte & Superior ore and 1 gm. calcite.

Mr. Williams: About two-fifths of an ounce, isn't it?

A. I don't think in ounces very quickly. We add 30 cc. of water.

3635 Mr. Williams:

Q. 185. At what temperature?

A. 37° C. 2 drops sulphuric acid and one cubic centimeter of olive oil. 1 cc. was the full limit that I thought necessary. That makes 9 per cent.

Mr. Scott:

Q. 186. Does the oil form a layer, doctor?

A. It does form a layer.

Q. 187. Over the entire contents?

A. Yes. I verified that before. Now, that is the one second, used as a figure of speech, for the production of froth, which is merely an air froth. There was pressure as can be seen by the fact that it squirted a little bit there. A slight additional agitation will continue the result. (Agitating the test tube again.) We have there now three-quarters of an inch of froth. And that gives us all that was described by Froment, metallic spherules pressed together closely forming a so-called magma which to all intents and purposes, looked at from above, has all the appearance of the froth which had been produced by other modes of agitation. We have there the clear metallic coating, the spherule formation and appearance and everything that has been described. That has become vuite pronounced now, it is quite dark. Of course this — a zinc ore. With a copper ore the distinction in color is even sharper.

Q. 188. And do you plan an experiment in the Gabbett of the California Journal process?

A. Yes.

Q. 189. We might do that now.

3636 A. An experiment has been arranged for to illustrate the procedure of the California Journal of Technology which was to produce the foam effect by utilizing a form of mechanical agitating apparatus to produce the froth effect, which was quite well known from 1889 on and of course known in 1903 when this article was published in the California Journal of Technology. I refer to the Gabbett cone mixer which was patented in England in 1889 and patented in the United States in 1891, which was 12 years before the appearance of the California Journal of Technology. There is being

used here a copper ore. The California Journal of Technology referred to there tells of copper ores as well as the tests with the molybdenite. The quantitative results which were given in that publication refer to molybdenite, but it was also tested with copper ores as stated by them, but not quantitatively. We have 250 gms. of copper ore, chalcopyrite ore.

Q. 190. You might describe the different ingredients.

A. With 250 gms. of this chalcopyrite ore we take 1250 gms. of water at a temperature of 25° C., 13¼ gms. fuel oil, California fuel oil, a paraffin product, which is equivalent to 5.3 per cent relative to the ore. The foam effect was obtained by these students who published this article with varying amounts of oil relative to the ore as low as two and a fraction of a per cent up to nine per cent. 3 cc. of concentrated sulphuric acid. Sulphuric acid was used by them as well as salt solution in their experiments in producing the
3637 foam effect. The agitation will take place in the Gabbett cone machine, five minutes' agitation. All of the elements which are here present in this experiment are justified by the statements made in the California Journal of Technology or by the knowledge which was available at that time.

Mr. Williams: Just note that the temperature of the water was 25° C.

A. I have that; I read it a minute ago. We are endeavoring to get the exact amount of the fuel oil by weighing, by difference in weight, weighing the beaker containing the oil and pouring a certain amount in and then weighing the beaker again and then taking the difference in weight as the amount taken. (Test 38.)

You can see the result of the foam produced after the California publication.

The Court: What was the oil?

A. The oil was 6.1 per cent instead of 5.3 per cent, as they added more than they intended to.

Mr. Williams: I think we ought to have the tailings for assay if any assay is made because we cannot see them in this machine and don't know what their color is. If possible, let the tailings be assayed as well as the froth, so as to get some idea of what the operation has accomplished.

Mr. Kremer: Do you want a sample of it?

Mr. Williams: Yes.

The Witness: While that is being gotten I would like to say that the California Journal of Technology published in that issue
2638 the basis for all three experiments. Two of them have been standing upon the desk here in sight for a week or more.

Q. 191. Since the day which the record will disclose?

A. Yes. One with a dilute sulphuric acid and the other gotten in a salt solution with an amount of oil corresponding to that stated in the publication and gotten by agitation only in the tall cylinders, and illustrating what was there called the foam effect. In this third experiment we have taken the same ingredients and have gotten the

foam effect in the form of a definite froth, which is, however, no more definite than what was shown there by putting——

Q. 192. (Interrupting.) That which is shown in the cylinders?

A. No more than what is shown in the cylinders by applying mechanical agitation instead of the mere shaking, the form of apparatus being one which was quite well known, in fact had been patented in this country 12 years before the publication of the California Journal of Technology paper.

Q. 193. Do you know, doctor, of any other apparatus suitable for that purpose that was also known at the time of the issue of this California Journal of Technology?

A. The Johnson cone mixer was also known.

Q. 194. Can you refer us to anything that shows that in this record of the Hyde record, which is in this case?

The Court: It seems to me I saw a churn in the Hyde record too.

3639 Mr. Scott: Page 966.

A. The Johnson cone mixer, as it is called, is illustrated in the Wolf patent which appears as patent No. 787,814, page 966 of this volume 3 of the Hyde record.

Mr. Williams: Page 966 of complainant's record is the Wolf patent.

A. The Johnson mixer as it is called, which was shown in the Wolf patent was referred to by Mr. Henry L. Sulman in the Hyde record, volume 1, page 274, in answer to cross-question 149 on that page: "You have said that this Johnson mixer was well known at the time of the Wolf patent. I note that the patent was issued on April 18, 1905, upon an application filed in May, 1903. Did you intend to include one or both of those dates in your answer? A. I intended the earlier date. Mr. Sulman testifies that this Johnson mixer was well known in May, 1903. The California Journal of Technology appeared in November, 1903, six months or more after the time at which Mr. Sulman testified the Johnson mixer was also well known. We have there two very efficient mechanical forms of apparatus."

Q. 195. Explain the apparatus while we are on this subject?

A. I would rather refer to that again in my other testimony. I will come back to that.

Q. 196. Just as you please, doctor.

A. I have nothing more to say on the Froment at present.

3640 Q. 197. Then, doctor, suppose we get your idea on the Kirby process, shown in the Kirby patent 809,959.

Mr. Williams: Patent printed on page 738, defendant's record in the Hyde suit.

A. I think next——

Mr. Scott: Doctor, before you go on, I can't remember whether you commented upon this froth, and told us its appearances and structure?

A. In a general way only.

Q. 198. I would like to have it.

A. The froth produced by this experiment with the Gablett cone mixer and intended to illustrate the publication (procedure) of the California Journal of Technology, is a very decided mineralized froth possessing the heavy mineral coating which has been seen in similar froths produced by other processes, and I am satisfied from the corresponding experiments made simply by the shaking in the tall cylinders that the froth here obtained will be a very durable froth. It is of course as seen now a distinct separated froth. The liquid below is clearing rapidly and we cannot see the tailing, but I have no doubt but what the distinction will be very sharp between the froth and the tailings; and therefore it is to my mind as complete a separation under the influence of aeration by agitation as is ordinarily accomplished by following the process of the patent in suit.

Q. 199. How would you say that the structure of this froth compared with Professor Bancroft's definition of an agitation froth?

3641 A. I can see quite clearly the appearance of the rounded cells, which of course are filled with air, and the walls of which are of thin layers of oil in which cell walls have concentrated the mineral sulphides, thereby stabilizing the froth, and in every respect corresponding to the description of what a froth is composed of. The peculiar physical appearance of the froth, that is, the pitted structure, and the other characteristics which we become acquainted with by the photographs are also quite noticeable in this froth.

Q. 200. I think you referred to the fact that the authors of this California Journal of Technology described particular experiments in which the quantity of oil ranged from two and a fraction up to eight or so?

A. Nine.

Q. 201. I presume in view of that you do not consider it material that a little over six per cent of oil was used in this experiment instead of 5.3 that I think that you planned to have used.

A. No, the only material feature is we kept within the range which is indicated there in that California publication and it is distinctly above the range which is claimed in the patent in suit.

Q. 202. Now, doctor, after this interruption you may go on?

A. I will turn to the Kirby patent, United States Patent No. 809,959, patented January 16, 1906, application filed December 14, 1903.

We can best understand the Kirby patent, what it means and what it achieves by taking his statement of steps as given on

3642 page 1 of the patent, beginning with line 65: "The process, as an entirety, in its best form for use with Rossland ores for the purpose stated consists in the following steps: First, in thoroughly agitating together (*a*) the pulverized ore or mineral material; (*b*) enough water to make with said pulverized ore a flowing pulp, and (*c*) a solution of bitumen in a thin distillable hydrocar-

bon liquid as kerosene, these materials to be so thoroughly agitated together as to finely subdivide said solution into small globules and bring said globules into contact with substantially all of the pulverized mineral particles which will, by preference, adhere to them."

The Witness: This is the first step, which they have described, the agitation. Now, we will note with regard to this agitation that Kirby speaks here of thorough agitation. The term "thorough agitation" appears twice in this paragraph which has been quoted from his patent specification. In several of his claims, notably in claims 1, 2 and 3, he used the expression "violently agitated," as applying to his first step of the process;—violently agitated. Now, Kirby's agitation or mixing tank is shown in Figure 1. There are four figures attached to this Kirby patent, and in Figure 1 we have shown Kirby's agitation or mixing tank at the extreme upper left hand corner. This agitating device is described on page 3 of his patent, line 100, as follows:

"In the mixing tank a vertical rotating shaft A is mounted
3643 having, preferably, a lower bearing similar to that which is provided for shaft B, and which has been described. Arms A^1 are attached to the shaft near its lower end, and lifting plows are secured to the outer parts of these arms, and radial plows to the other parts thereof, just as in the separator tank. This shaft A is to be rotated rapidly, and the result is a sort of commingling of the various parts of the charge, which result is facilitated by the currents created in the charge by the action of said plows, the direction of said currents being indicated by the arrows in Figure 1.

We have noted there the arrows, and it shows that the liquid is rising near the outer circumference of the tank, and apparently descending along the central shaft on either side. That is a clear diagrammatic illustration of the vortex motion obtained by this machine. The vortex motion is there illustrated by the dotted curved line, illustrating the upper surface of the liquid, which is shown there curving inward to the center. When the rotation is kept up that can be quite easily seen in all these mixing devices, for instance like the Gabbett mixer and many others we have these radial arms rotating. We have here indicated not only the direction of the vortex current by those arrows, but also by the dotted lines in these liquids, showing the same drawing down of the liquid which takes place in the Gabbett cone mixer.

Now, this necessarily involves the drawing in of air with that motion; you also get asome entraining of the air as practiced
3644 in the Gabbett mixer described in the first step of the patent in suit.

Kirby tells us practically that shaft A is to be rotated rapidly, and insists in his claims, on violent agitation in connection with this first step. Moreover, I would call attention to the fact that Patent 809,959 is for a process, and his illustrations are merely for the purpose of showing the way in which the process can be carried out. This is clearly stated by him in lines 26 to 29 on page 1, as follows:

"In the drawings, Figure 1 is a diagrammatic view of an ap-

paratus with which the process may be practiced, the several parts thereof being shown in vertical section."

At the time of the application for the Kirby patent, two other mixing devices adapted to produce aeration by rapid agitation were well known and available; one of them has been referred to just recently, the Johnson mixer, in patent 787,814 to Wolf. Mr. Sulman has testified in regard to this in defendant's record in the Hyde case, page 274, first, that this Johnson mixer was designed to produce much the same effect as the Gabbett cone mixer. I would like to refer to that and verify it. Mr. Sulman testified as follows: "The apparatus was designed to produce much the same effect as the apparatus generally known as the Gabbett or cone mixer. In this instance the radial arms supporting the inner tube acted as efficient baffles, preventing the undue rotation of the liquid as a whole."

3645 Now, that is best understood if we refer to the Wolf patent and see what he meant by radial arms at the sides. In this Wolf patent, the value of the radial arms is there referred to, and Mr. Sulman says in regard to them, that the radial arms supporting the inner tube act as efficient baffles; in other words, the rotating liquid starting to rotate by this rotating device here, is broken constantly by those baffles, or those arms acting as baffles. Mr. Sulman also states, in answer to the next question following, that this Johnson mixer was well known in May, 1903.

The other aerating and agitating apparatus was the Gabbett cone mixer, which was patented in England in January, 1889, and patented in the United States in January, 1891. I have already referred to the fact that both of these dates, the date of the patenting of the Gabbett cone mixer and the date of the knowledge of the Johnson mixer as testified to by Mr. Sulman—that both of these dates were prior to the California Journal publication dates.

Now we come to the consideration of the Kirby patent—We come next to the results of this first agitation step. The result of this first thorough or violent agitation is stated in lines 109 to 114 on page 3: "This shaft A is to be rotated rapidly, and the result is a thorough commingling of the various parts of the charge, which result is facilitated by the currents created in the charge by the action

3646 of said plows, the direction of said currents being indicated by the arrows in Figure 1."

As I have just explained, these currents constitute a vortex, which, with the rapid agitation, must involve the entraining of air. The second result, however, is stated by Kirby on page 1, line 79, as follows: "In allowing the hydro-carbon coated particles to float to the surface of the mass, and in rendering this separation substantially complete by gently agitating the mass and by injecting gas into the same, and preferably also discharging into the mass fine streams of the solution. When the separation is completed, the floating hydro-carbon concentrate is removed for subsequent treatment."

The statement of the results that the hydrocarbon-coated particles float to the surface of the mass, means that they are there as a part of a froth on the surface of the air bubbles developed by the entrain-

ing of air in the rapid motion followed by the vortex action of the liquid, with the air bubble production.

There is only one conclusion, as I say, to be drawn as to what this float was; this float could only have been an aerated froth, coated with mineral particles. Now, it has been shown experimentally in two experiments already in this case here in court—It was shown by Mr. Phillips in producing the product obtained with 25% kerosene in the small glass jar, the remnants of which are there on your honor's desk, and it was shown by Mr. Dosenbach in a larger glass jar using the proportions of this kerosene indicated by
3647 Kirby—in other words, these experiments made in connection with this trial have illustrated what I am here describing as the necessary result of the several steps of agitation given by Kirby in his patent.

Now, we get to the second step. The second step is clearly stated to be a secondary, and not a primary part of Kirby's process. In the language of the patent, page 1, lines 81 to 85, after what I read in regard to the floating to the surface of the mass, it says, "And in rendering this separation substantially complete by gently agitating the mass and by injecting gas into the same and preferably also discharging into the mass fine streams of the solution."

Again on page 2, in lines 44 to 48, the same matter is referred to as follows: "The introduction of a gas, preferably air, into the mass, which is the additional novel characteristic of the second step of this process, assists in the flotation of the hydro carbon coated particles." Notice the word "assists".

The character of the second step as a complementary step is clearly illustrated in these two citations; as steps to make more complete the original froth separation, and this secondary process is characteristic of practically all agitation processes, and is very clearly stated in the patent in suit, as desirable.

Kirby says again "the invention consists in the process hereinafter described and in the several steps thereof, all of which will be definitely set forth in the claim." We have a clear recognition of the fact that there is a primary and a secondary step, and the
3648 two may be taken as individual steps, combining to get what he considers to be a more complete rising of the particles and accomplishment of his result.

Again, on page 1, line 95, the matter is referred to. Kirby says, "The use of a gas to assist in the flotation of the coated particles, as set forth in the description of the second step of the process, is radically new in this art, irrespective of its association with the other steps described." There is another statement which appears shortly after that, which I think is a gratuitous statement, not connected with the description of the process, but which sometimes is considered as having a very notable bearing upon the process. I wish to call attention to that:

Kirby's suggestion in line No. 102, that his second step could be used advantageously in connection with the prior processes using thick, viscous oils, to prevent the flouring, has nothing to do with the

present invention, and in view of the first step, it can not be. It was evidently a bulk oil process to which he was referring.

As to this view of Kirby's that the use of a gas would be a good thing in connection with the thick viscous oils, that is a supplemental step, and it is not necessary for me to say whether I agree with Kirby as to that or not, because I have not tried that idea, but it has no connection whatever with the clear-cut, two-step process which is described by Kirby, the first step and the second step.

Whereupon further hearing was adjourned until Thursday morning, May 3d, at 10 a. m.

3649 Thursday, May 3rd, 1917—10:00 a. m.

Mr. Garrison: From evidence recently adduced by the defendants in this suit, we have been convinced that in addition to infringing the patent which is pleaded in this suit, they have also been infringing another patent owned by the same plaintiffs, which we know colloquially as the soluble frothing agents' patent No. 962,678 of June 28th, 1910. We purpose filing a bill to protect our interests with respect to that patent but it occurred to us that since Mr. Scott and Mr. Sheridan are thoroughly familiar with all of the issues that can arise under that patent because in their defense of the Miami Copper Company during the nine weeks' trial at Wilmington and the six days in the Court of Appeals at Philadelphia that patent was one of the points in litigation and all of the evidence was minutely gone into and briefed and debated, that they would perhaps prefer to have us bring that patent into this suit and join issues upon the question of our right under that patent in respect of their acts and try that out at this time. If they so elect and are ready to join that issue now and to proceed with this trial, we are willing to adopt that course. Otherwise we shall pursue by an independent bill the right which we have to litigate that question by itself. I will give them the opportunity if they feel it would be a better service of their interests, to have litigated in this suit now, to have them elect so to do and we will then adopt that course.

The Court: Of course there is no reason why such a propo-
3650 sition in court should embarrass counsel and yet personally I am always reluctant to see such things broached in court for fear counsel may be misunderstood. If there are any negotiations or any proposals of that nature they ought to be taken up with counsel, it seems to me, rather than with the court.

Mr. Garrison: The reason this matter is brought in open court, your honor, if the defendants in this suit had any purpose to claim that it would have been a better proceeding for them to have this other question litigated in this suit, we now give them that opportunity. We do not want to embarrass them and I do not care whether they make any response or not. I simply wish to give them the opportunity now in open court to elect to have that issue tried in this case, if they so elect. If they do not so elect, that is a matter for them to determine, and if we consider it is necessary to save our rights we shall do otherwise. I should not have embarrassed

the court with this although I do not wish to be fronted in this or any other court with the suggestion from them that they would have welcomed that issue in this suit, because it is a fact that a very great deal of the testimony with respect to the prior art at least—well, with respect to any infringement also, that is relevant in one case will be relevant in the other. It may be that when the other case is called for trial if I had not made this statement they would have said, "We would have preferred to try that question in the other suit."

The Court: Oh, well, if it wasn't a splitting up, that wouldn't count for anything.

3651 Mr. Kremer: Does this all appear upon the record in this case, if your honor please?

The Court: If, as he says, he conceives he is protecting his right, it possibly should.

Mr. Kremer: I don't like this constant colloquy, but if that is so we desire to make this statement: that this is the first time that we have ever heard any intimation or suggestion of this sort; it was not made to us outside of court; neither has it been mentioned before in court.

The Court: Well, I think anyhow any right that is to be preserved, would be preserved by offering such a bill or by a modification possibly.

Mr. Sheridan: While I do not like to cast any aspersions on counsel, but it is very cleverly put. I have refrained from making any remarks to the court at all. These gentlemen know that a defense to this patent is absolutely different from the defense to the patent in suit. We haven't a word in evidence that would controvert the validity of that patent, that would controvert its being an invention, or that we did not infringe it, and to bring that and put it into court would mean an adjournment of this court so that we could prepare our witnesses, four or five weeks. The gentleman that made this motion has had vast experience in court and knows how absolutely impossible that would be.

The Court: Well, I suppose there is such a thing as strategy, but it does not count for much before the court. If it was before a jury it might be different. That is why I say I like these things

3652 to come up out of court. Of course I do not criticise counsel. You have your view and so has he, and let's give you both credit for good faith, and as it is you may proceed with the case on trial.

Dr. SAMUEL P. SADTLER resumed the stand for further

Direct examination.

By Mr. Scott:

The Court: I wish this morning, since the court has on two occasions rather strongly intimated—and that is often done to draw your fire—to say—that it can not see the likeness between this machine in the Fryer Hill publication and the Everson process and the one in suit—Dr. Sadtler has said that he understands that process and

I would like him to go into that a little more fully and explain it. He is speaking now as an expert. I don't want you to feel restricted because I have already expressed a tentative opinion.

Mr. Scott: Very well, sir.

Q. 203. Doctor, will you take that up right now?

A. Perhaps I had better finish the discussion that I was in the midst of as to Kirby, and then take it up.

3653 Q. 204. Well, you had better go into it right now I think, and show the machine.

Mr. Scott: The Fryer Hill publication is in complainant's record page 738, and the Everson patent is in defendant's record page 607.

The Court: It seems to me to be recognized or conceded by both parties that this Fryer Hill publication had reference to the Everson process.

Mr. Scott: That was conceded in the Hyde record.

Mr. Williams: It was not conceded, if your honor please.

Mr. Scott: The expert testified to it—I will correct myself; the two experts for the plaintiff testified that the operation described in the Fryer Hill publication was evidently an application of the Everson process, Dr. Chandler, and Dr. Liebmann.

Mr. Williams: I think the substance of that testimony was this: in the Fryer Hill publication there is a reference to the use of sulphuric acid. In the Everson patent there is a reference to the use of sulphuric acid. There is no other resemblance between the two.

The Court: I had not noticed the difference or the resemblances, but I had that impression, that both parties were treating it as an illustration of the Everson patent.

Mr. Scott: I will quote the testimony later, so as not to delay looking for it now.

Mr. Williams: There is no positive evidence connecting
3654 the two; it is a mere matter of resemblances; it must be treated as two separate publications, each standing on its own legs.

Mr. Scott: That is a matter of the evidence.

The Court: Yes, you can argue the evidence later. I wanted to be clear in my conception.

Q. 205. Have you the Fryer Hill publication before you, Doctor?

A. I have.

Q. 206. Now, without reading through this, I would like to refer to the first passage descriptive of the machine that was used.

Mr. Scott: Near the bottom of the page, if your honor please, about four lines from the bottom of page 738, it is stated that after the ore is prepared, after it is crushed and rolled to such a degree of fineness as to enable it to pass through a 40 mesh screen, the ore, dry, is thoroughly mixed with oil, after which it is placed in a circular tank or receiver—which was represented by the glass vessel we had here, which seems to have been taken away but will be brought back.

The Court: Yes, I have a plan of it.

Q. 207. Now, Doctor, I think the best way to make it clear to the court would be for you to take the chair, where you can point out to the court on the drawing there, and you may place letters on the drawing as you go along so that in the record it will be apparent what you refer to, unless the drawing is already lettered.

3655 A. The first element in the apparatus described is the circular tank in which the mixture of ore and oil, previously made, is introduced. The ore while dry, is thoroughly mixed, after which it is placed in a circular tank or receiver. Here we have represented the circular tank or cylinder, this being an outline of it. This is the vessel of glass which has been taken upstairs and will be brought here in a moment; that is the containing vessel. Through the center of that cylinder runs a rotating hollow tube down here. This runs up, and here is the pulley by which the rotation is effected. This rotating hollow tube—there is a perforation which we will mention in a moment, but it is a hollow tube running down to where this door is attached. To the bottom of which tube is attached on two opposite sides a couple of fans. That is what we mean here, the fans. I will go presently to the apparatus and follow it there, but for the moment I am following it on the drawing. These are the two rotating fans, the lower edges of which are unevenly cut, in order to send the lighter particles of the ore and the lighter mixture to the outer side of the drum or cylinder. By rotation of this tube driven by the pulley, these fans are rapidly rotated, and by the aid of these serrations down here there is a very thorough mixing and churning again of the ore pulp and oil mixture, because we have now present the mixture of oil and ore which has been prepared, and the added water. The lighter particles of the ore and oil mixture are sent to the outer side of the drum or cylinder. This rotating

3656 hollow tube is perforated at or near the bottom. Here is the perforation. When the receiver is thoroughly charged and rotation is begun, acidulated steam—sulphuric acid being used—is introduced through the tube. This tube being hollow, allows of that introduction, passing out through these perforations, of acidulated steam. Now, that has a very distinct influence on the separating results; it gives the heat desired, and it gives the notable action of the acid which was referred to by Everson as one of the features of her discovery that, in the presence of mineral acid or mineral salts, for that matter, the selective action of the oil for the mineral is more pronounced and the separation of the mineral and the gangue is more perfectly accomplished. Steam is introduced in the tube and is forced to the bottom of the mixture while the arrastra-like fans—which refers to the construction and appearance of these two rotating fans—arrastra-like. It does not mean that they are to be worked as an arrastra would be worked; they are arrastra-like in shape and in their general appearance, but it is very obvious from the accompanying description there that there is where the resemblance ends. These arrastra-like fans are rotated rapidly, and keep the whole mixture in motion, and the action of the revolving tube,

the fans, and the introduction of the acidulated steam—now we have the effect—causes the lighter portion to float to a point just above the center of the receiver. The float is formed here,
3657 and that float is an aeration froth formed by the rapid rotation of a form of apparatus calculated to produce the vortex motion, and calculated to introduce air from above, and thereby entrain air, and the entrained air furnishes the air bubbles, and the mineral particles concentrate in the film of air bubbles and gives the mineral-charged froth, if we take the aggregate of the air bubbles—to congregate slightly above the middle of the cylinder. It says "float to a point just above the center of the receiver." The word float is expressive; that arises and remains as a floating froth or scum—to a point just above the center of the receiver, where there are suspended two semi-circular doors. In the beginning of the operation these doors hang vertically, as we will see in a minute with the apparatus, and their only influence in the early part of the operation is to act as baffles, because it can be clearly seen by the inspection of the special apparatus that has been presented, that a suspended or fixed vertical plate, or a fixed vertical wire frame as seen in the Gabbett cylinder apparatus, will act as a baffle to break up the continuous rotating motion, and thereby to thoroughly aerate, because the breaking up of the continuous motion is what causes the drawing in of air, and a thorough mixture,—and the thorough mixture is accomplished by the aid of these baffles, as well as entraining.

Now, these same semi-circular doors, after this float has formed, are just in the proper position so as to be raised, and they
3658 are drawn up so that they close and form a floor as you might term it, just under the float. I have carefully observed the operation where it was carried out in that apparatus, and I was able to recognize that the floor produced by the drawing up of the two semi-circular fans came very exactly under the level of the float which was desired, and when the oil passed above that, lifting its precious freight burden—that is, there is the float with the oil and its precious burden—then that will cause a water drainage through the perforations in the doors. The perforations are very small, and I will call attention to the fact in my discussion that that Fryer Hill apparatus, in allowing that drainage of the water does not permit the drainage of the heavy oil, and that answers the purpose of allowing the drainage of the water, and the mineral and oil is then carefully removed to settling barrels—and so on. After that we are not concerned with what becomes of it. But in carrying out of the operation, after these doors have been raised, constituting a floor just under the froth, and the water underneath that floor, then, by lowering this jar, it was possible to draw away everything but the froth, supported on that floor, because after the bringing together of the doors, everything else was drawn away.

Q. 208. The lowering of the jar would be just the same as the raising of the doors?

A. Yes. Of course we could, by changing the mechanism have drawn off everything above that floor, but it was very much

3659 more convenient to do it this way, and then the froth was left, and after that it was entirely possible to remove the froth entirely clear and by itself, as was done, and with the aid of a washing bottle, to wash it off into a bottle.

Q. 209. Explain to the court what your reasons are for saying that that is an aerated froth.

A. I am satisfied of that after having read the Everson patent, with which I connect this publication, and with which Dr. Liebmann connects this publication, as in his opinion an experiment or an effort to carry out the Everson patent—after having read both of these and seeing the operation of it, I am satisfied that the rapid revolution, and Everson tells us there—In floating "the concentrate after thorough agitation of the mass and detachment of the sand"—there are the two main points in the Everson patent. Now that operation is aided by these fans, and aided by the introduction, after the revolution starts, of acidulated steam, and the result of that agitation is the formation of this froth.

The words "and detachment of the sand" refer to the separation of the gangue. The gangue separates, settles, and ultimately is drawn off and of course that leaves the froth. This froth can only be an aerated froth because of the conditions of agitation, in my opinion, being rapidly agitated with the same kind of device that was used in a number of other illustrations.

Q. 210. Has the quantity of ore anything to do with your conclusion regarding the character of the float?

3660 A. The character of the oil which, according to the wording of the Everson patent was 17 per cent, has no effect at all upon the question of whether a froth can or cannot be formed. A froth is readily formed with 17 per cent or a fraction of kerosene oil or a paraffin as described by Everson.

Q. 211. Would any other kind of flotation concentration be effected with 17 per cent of oil?

A. You cannot effect the Elmore form of buoyancy flotation.

Q. 212. For what reason can you not effect the Elmore form of buoyancy flotation?

A. In the first place the amount is absolutely inadequate to raise anything more than a very minute fraction of the mineral content; and the second place the agitation absolutely bars it. The agitation she describes absolutely bars the getting of the Elmore effect.

Q. 213. What authority have you for that statement?

A. It has been testified to by experts on both sides and particularly by Dr. Leibmann that the Elmore process is to be carried out with as little agitation as possible. I have myself carried it out with the greatest care and using different kinds of oil, the thick viscous oil, to carry out the Elmore process in a bottle, slowly revolving, and was able to get the Elmore effect with very slight evidence of the breaking up of the compact layer. With a thinner oil than the oil residuum described by Everson you cannot get the same result.

3661 Q. 214. Did you ever compare the effect of agitation described in this Fryer Hill publication and the Elmore bulk oil process?

A. I have done it independently, following that test of the Everson process with a light hydro carbon of the kerosene type, and got a very excellent froth product with the kerosene; whereas, as altered by trying the Elmore method, I have failed to get a notable result.

Q. 215. Suppose the other conditions were corresponding to this Elmore process and you were to agitate violently with the same kind of oil, what would happen?

A. We would get a froth because we have gotten a froth with very heavy oils, the so-called fuel oils, the heavy oils have been used in a number of experiments.

Q. 216. You might just show the manipulation of that.

The Court: I think I remember that pretty well.

The Witness: There is where the——

The Court: I think I remember that machine. I remember the experiments very well.

The Witness: I have dwelt upon these experiments which seem to me to show the same—carry out the same principle. That is, the agitating mechanism which is driven with sufficient rapidity is certain in my mind to entrain air as well as to thoroughly admix and bring them all in contact with the sulphide particles, which is necessary if they put this hollow tube in the center prior to agitat-
3662 ing—through that acidulated steam is injected.

Q. 217. Tell the court what that acidulated steam—why that acidulated steam was not used here and what was done instead?

The Court: Mr. Dosenbach explained that.

The Witness: To connect these three things together, I connected the working of the Everson patent, I connect the description of the apparatus in the Fryer Hill publication and I connect what was undoubtedly perfectly available to the Criley and Everson publications, in which, while the apparatus is not described, we have the result described very minutely. A thick oil was used in this case and to water heated near to boiling was added enough sulphuric acid to give it a tartish taste. That gives us our acidulated hot water, corresponding to the acidulated steam, which follows immediately after in the Fryer Hill publication as well as in the Criley and Everson. In that case we have stated "enough sulphuric acid to give it a tartish taste." This acidulated water is then mixed with the mass of oil and ore. It does not refer to this question at all of its being injected in the hollow cylinder. "A thick scum of sulphurets rose to the surface and was skimmed off."

Q. 218. Doctor, now that you have been referring to this subject and the use of the word scum, I think it would be a good time for you to state your understanding of the word "scum" and how it has been used in these various patents in litigation?

3663 A. I have made a study of that because it seems to have some interest. I have made a search of the way in which the terms "froth" and "scum" are used in the various patents of the Minerals Separation, Limited, taken from the patent records. I have found nine English or American patents which I will enu-

merate and state how they used that term. To begin with the United States patent 835,120, which is the patent in suit, this patent uses the words "froth" or "scum" as synonymous in the specifications at four different places, sometimes saying "froth" or "scums" and sometimes "scum and froth." British patent, 7,803 of 1905, which corresponds to this foregoing United States patent, that is the patent in suit, also uses the expression "froth or scum" in four different places, taking them as synonymous terms. United States patent 835,143 of November 6th, 1906—that is the same date as the patent in suit—to Sulman, which is sometimes referred to as the boiling patent in which boiling water is used, uses the expression "froth or scum" to designate the result of the agitation and heat in two different places.

British patent 26,852 of 1908 to the Minerals Separation, Limited, sometimes spoken of as the aromatic hydroxy-compound patent uses the expression "coherent froth or scum" twice, and once the additional expression "froth or scum."

United States patent 962,678 of June 28th, 1910, which corresponds to British patent 2,359 of 1909 also uses the expression "froth or scum" and once the expression "coherent froth or scum."

3664 British patent 28,173 of 1908 to Sulman and Picard sometimes spoken of as the alcohol patent, uses the expression "coherent froth or scum" twice in the specification, and in three of the six claims they use the expression "froth or scum."

British patent 2,359, of 1909, to Greenway, Sulman & Higgins, known as the soluble frothing agent patent, uses the expression "froth or scum" three times and once also the expression "coherent froth or scum."

British patent 23,870 of 1910, to the Minerals Separation, Limited, and Nutter, uses the expression "froth or scum" three times in the specification and once in one of the claims.

United States patent 1,099,699 of 1914 to H. H. Greenway for aromatic hydroxy-compounds uses the expression "froth or scum" in the specification. That is the series of patents considering all of them as either taken out by or assigned to the Minerals Separation Limited, and it represents their use of these terms "froth" or "scum."

Q. 219. I have found one of these passages in the Hyde record, page 544 of the complainant's record in the Hyde case, Dr. Leibmann says: "The Fryer Hill publication of 1889 is clearly a further development of the Everson patent."

A. That is what I referred to.

Q. 220. Then he goes on in connection with that, coming to the Criley-Everson publication that the doctor just referred to and quoted, Dr. Leibmann says: "The Criley-Everson publication

3665 of 1890 is a modification of the Everson process as described in the Everson patent" and then goes on to discuss that, and I think anyone such as Dr. Leibmann and Dr. Sadtler, would see the earmarks are all there as to the relation of the two publications, both as to the time of the publication and the date of the operation and the kind of the operation.

Mr. Williams: I can also give your honor one or two references on that topic. I suppose it is timely.

The Court: Yes.

Mr. Williams: On page 388 of the same volume, volume 2, complainant's record, Dr. Leibmann says in answer to 8-Q.: "The extract from the Daily Herald Democrat of October 30th, 1889, refers to a new method of treating dry silicious ores and an experiment of the concentration of such a dry silicious ore containing silver is described therein. There are several facts which induce me to believe that this extract refers to an experiment according to the previously discussed Everson invention, to which some new developments have been added. The extract states that the new method referred to and was suitable for the treatment of silicious ore. A similar statement is contained in Everson's specification. It is further stated that the ore treated was an ore containing silver and a concentration of the silver particles was obtained. Everson states that her process will probably only be valuable for the treatment of ores containing precious
3666 metals, such as gold, silver and copper. According to the report, the ore is, after being crushed and while dry, mixed with oil, which again is in accordance with the Everson process disclosed in 348,157. The quantity of oil to procure thorough mixing of ore and oil must be somewhat similar to the quantity specified by Everson. The apparatus is new and apparently also the mode of agitation which is described." And then I do not wish to read further. And then there is a reference to the arastra-like fan, and the fact that the arastra is a slowly moving, grinding apparatus which is well known in mining. But I think there are some one or two further matters in defendant's record. There is a concluding statement which made it quite clear that this was just what you might call a resemblance in particles and nothing more. I can't put my hand on this just at this minute and I won't ask the court to stop for it. That was in another suit.

The Court: It is in the record you say?

Mr. Williams: It is all in the record.

Mr. Scott: Doctor, I think you may proceed with what you were discussing.

A. When court adjourned I was discussing the Kirby patent and had spoken of the first step and the second step of the Kirby patent and the fact that we could not consider the result, in the light of what would be accomplished by one of these taken separately, but Kirby intended them to be taken as a first and as a second step, the first step to be followed by the second; and he points out that
3667 the second step is a supplementary step. I proceed now to the quantity of oil used by Kirby. When we come to consider the Kirby patent, 809,959, when we come to consider it is the thin, distillable hydrocarbon oil indicated by Kirby as adapted to his purpose, we have several things to note. In the first place it is entirely insufficient to allow us to practice the Elmore buoyancy oil process which requires from 100 to 300 per cent of oil, reckoned upon the ore. Moreover, it is not the type of oil that is needed for the successful practice of the Elmore process, namely the viscous oil of the

character of petroleum residuum, of heavy gravity, and distinct viscosity. This thin, hydrocarbon oil of Kirby would not hold together without flouring—that is a breaking up of the contact layer into separate bubbles which no longer have the power of holding mineral particles by pure buoyancy flotation in the same way that the compact layer does—this thin oil would break up and develop flouring even under a very slight amount of motion used, if carried out by the Elmore method of operation. This I have experimentally verified in the experiment which I have carried out where it was tried in comparison with thick residual oil—I refer to the experiments which were spoken of a moment ago by Mr. Scott, which I carried out using a rather wide bottle in which was placed the ore, pulp and water, on which was a layer of heavy residual oil, and then by agitating that slowly—and the same thing was carried out by other witnesses in the trial at that time—by agitating
3668 that slowly we developed the Elmore effect, that is the gathering together in the heavy oil residuum layer of mineral particles, where they were held by reason of the flotation power, we will call it, or the buoyancy of this oil, the gravity of the oil being approximately .9 as compared with the gravity of water at 1. So that there was a flotation power there of .1—that is one-tenth,—and supposing that we had equal volumes. In that way the Elmore effect was carried out and in the Elmore operation that was described in the California Journal of Technology it will be remembered that there was the slow screw working in such a way as to bring entirely in contact the thick viscous oil and the mineral particles contained in the pulp and thereby to cause the thick oil to take up those particles. That was a slow motion and was comparable with what was done in a small way experiment, in a small test experiment in turning the bottle slowly through a number of revolutions. The same experiment, carried out with a thin, distillable hydrocarbon oil gives no result compared with the thick oil, because the thin oil in that turning process easily would develop the result called flouring and it is itself, because of its slight viscosity, incapable of holding its load without dropping very readily, so that it is notably inferior and has always been recognized in the practice as inferior to the thick residuum oils which are particularly adapted to the Elmore process and, as was stated a moment ago, using the same amount of oil and the same mixture of flotation pulp and applying the rapid agitation method you get a result analogous to
3669 what is gotten in the square jar there with 25 per cent of kerosene; that is a permanent froth which remained heavily mineral-laden. Most important of all, however, in considering this question of the use of a thin hydrocarbon oil by Kirby in that account is the violent agitation of thin hydrocarbon and the ore pulp, in his first patent. That, of itself—that alone, that is the violent agitation alone takes this Kirby patent out of the bulk ore category and brings it into the aerated and agitation class. If you can eliminate the first step of Kirby and for a minute suppose the Kirby process carried out by this slow rotation of his form of apparatus with these arms, and the injection of air, you might have a com-

bination of buoyancy flotation with a certain amount of ore particles raised by air bubbles, as has been described by other witnesses; but you cannot tear the Kirby patent in half and eliminate the first step, which is violent agitation. If you practice the first step, the results are such as make it impossible to have the Elmore result or the Elmore process.

The next point I desire to take up is: Will we get a satisfactory metallized froth with this thin distillable hydrocarbon of Kirby used in the amounts indicated by him? That this can be done with entirely satisfactory results was shown here in court twice, first in the experiment with the square jar with that milk-shake mixer used by Mr. Phillips, and of which the results are still there; and the other time by Mr. Dosenbach in the glass jar machine using a form
3670 of agitating apparatus very analogous to that shown by Kirby and obviously allowable under the Kirby patent, because as I said yesterday in testifying on this matter, the Kirby patent is a process patent illustrated by one form of apparatus but not tied up to that. And as I also said yesterday at the time of the Kirby patent application there were two very excellent agitating and aerating forms of apparatus known and particularly known in this art, the one being the Gabbett cone mixer and the other being the Johnson mixer, both of which were equally available in carrying out this, with the third form which is here referred to by Kirby. Now, the next question I take up is what was the nature of the froth produced by Kirby?

The froth produced by the carrying out of this first step of the Kirby process being the thin distillable hydrocarbon in the amounts as stated by him to be 25 to 75 per cent, the froth produced is an aerated froth, in which the air entrained by the rapid agitation with the form of apparatus illustrated by Kirby produces the air bubbles. The kerosene forms the material which holds up the oil films inclosing the air bubbles and in the presence of the air bubbles throughout the agitated mixture the metallic sulphides concentrate, in these oil films, stabilizes them and gives us therefore as a product a stable, mineral-coated air froth, which is the vital part of the aerated froth, mineral coated of the patent in suit.

This is the result, too whether we use the smaller or the
3671 greater amount of oil indicated by Kirby. I have personally carried out experiments in which I used 25 per cent of kerosene in practicing this first step of the Kirby process; I have used 75 per cent kerosene in the same form of apparatus and have obtained excellent, stable mineral froths, in both cases. They are thicker when using the larger amount of oil with sufficient agitation. The only difference in the result using from 25 to 75 per cent was a more copious mineral coated froth where the larger amount of oil was used. I, in fact, have carried out experiments using 5 per cent and running up to 75 per cent of kerosene.

I now would like to take up for a moment and discuss a dissenting opinion on this matter. I have expressed myself just now as to what I considered was the character of froth produced in the Kirby process, that it was an aerated froth and described it. I now desire

to turn to the opinion of Dr. Leibmann on that matter as given on page 437 of volume 2 of the Hyde original record, complainant's record.

Q. 221. Complainant's record?

A. Complainant's record, page 437. Dr. Leibmann there says: "Kirby's process consists in the separation of minerals from ores: (*a*) partly by buoyancy flotation; (*b*) partly by lifting the aggregates of mineral in oil, which are at the bottom, by air bubbles to the top, and removing the products of (*a*) and (*b*) together." I do not agree with Dr. Leibmann in this matter. I believe that this statement of his would make the first step—he puts it in two parts
3672 *a* and *b*—this would make the first step of the Kirby process, using a thin distillable, hydrocarbon and violent agitation as described in the section (*c*) in the specification to have as its result buoyancy flotation. Now, I have shown, in discussing this matter a moment ago that that is absolutely fatal to any Elmore result, and we cannot get buoyancy oil flotation if we practice honestly and as described in the patent the first step of the Kirby process. The operation of the second step, of slow agitation, is described by him as producing the lifting of mineral in oil, to air bubbles—of air bubbles, to the point——

Q. 222. As described by Dr. Leibmann, not Kirby?

A. As described by Dr. Liebmann as having the result which is mentioned in his statement of the second part of the result. That is a supplementary process and probably has that general result there stated. There was a slow additional raising of mineral particles, and undoubtedly by the aid of the injection of air and the currents produced thereby, which supplements the original result of the violent agitation.

Now, a few pages further on, in the same record, on page 442, in the continuation of Dr. Liebman's testimony, near the middle of the page, Dr. Liebmann says: "The experience which I have gained from experiments makes me doubt whether the assertion made under No. 3, viz., the possibility of the use of a thin hydro-carbon for the purpose of the recovery of the minerals, is a fact. In my view of it, no thin oil can be used with advantage, and the patentee
3673 himself describes that the mineral collected at the bottom of the layer of thin oil, which is near the water surface." Dr. Liebmann has here said that in his view and in the light of his experience no thin oil can be used, which I think simply states the weight of Dr. Liebmann's further experience, because I take now his second view rather than his first view—and that is in the same line with mine, that you can not use thin oil to advantage in trying to practice buoyancy oil flotation, and he doubts, therefore, whether the thing is practical. I doubt whether it is practical, but I see the point of the use of thin oil by Kirby if we practice the Kirby process in its entirety. Dr. Liebmann has well stated the difficulties of using a thin hydro-carbon oil for buoyancy flotation, and if we add to this statement the fact that from 25 to 75 per cent. of this thin hydro-carbon oil is recommended by Kirby instead of 100 to 300 per cent agreed upon as needed for the Elmore buoyancy flotation,

and if we add to this again as an additional element the violent agitation that Kirby advised, I see how impossible it would be to obtain any buoyancy flotation results in connection with the first step of the Kirby process, or as a summary—as a result of the combined steps.

I now pass next, in considering the Kirby patent, to the conditions of the removal of the froth, as stated on page 3, lines 37 to 41 in the Kirby patent. "The rotating movement of which—" And now we have passed the practice of the first and second steps, one
3674 following the other—"the rotating movement of which leads the floating scum of hydrocarbon liquid, air bubbles and concentrates, against the curved skimming bar, which is hung so as to assist and divert this floating layer and cause it to pass into the settling or washing chamber, box No. 29." We have here described a device characteristic of this Kirby patent, which is the exact equivalent of the skimming device which is in daily mill practice; that is, the froth is moved along from the surface of the spitzkasten by the continued motion of a slowly moving bar, which hangs just low enough to move the froth easily, without cutting down below the line of junction of the froth and the water, so that it really moves the froth by taking off the top of it, and the larger body of it, and in that way continually discharges into the launder. That is the case, with the skimming bar here, the movement of this accumulating froth or floating scum, it is called here, and that is just as strong a term as was used in the Minerals Separation patent; the floating scum of highly mineralized ore bubbles and concentrates into the washing chamber.

Now, we have next on page 4 of this patent the saving of the froth after movement by skimming, lines 12 to 17: "The stream of skimming enters the central cylinder, within which the water and the hydrocarbon separate, the former sinking while the latter, with the accompanying concentrates and air bubbles, floats in a layer as shown." The stream of skimming—Skimming is a very
3675 inexpressive word, but refers to what has been taken off by the skimming bar—The stream of skimming goes on, and the water sinks, while the latter, meaning the hydro-carbon with its accompanying concentrates and air bubbles, floats in a layer as shown. There is a clear indication here that we have the same form of combination of concentrates and air bubbles in an aerated froth that was skimmed off, and I consider it to have been the result of the practice of the first and second Kirby steps, one following the other.

We go now to line 17: "The stirring apparatus, No. 42, has its arms revolving gently within this layer, so as to break up and discharge air bubbles and assist the separation." If we have a compact layer of oil, with only incidentally a few air bubbles on it, this step would be entirely needless; it would have no meaning to it; but it has a meaning as read here. The arms revolving gently within this layer, break up and discharge air bubbles and assist the operation. We have seen in an experiment here the way in which slow rotation can discharge air from an aerated froth; in other words we can get the air out of the froth by slow rotation.

Then again we turn on this same page, further down, to line 31:

"The concentrates which fall to the bottom of the tank, accompanied by the hydro-carbon which adheres to them, are drawn off in a thick condition." That means that the froth and concentrates are drawn off in a thick condition, along with the hydro-carbon adhering to them, through the pipe No. 45. These descrip-
3676 tions follow clear through to the end of the description of the Kirby process and seem to me assurance that the practice of the first and second steps leaves him to deal with an aerated froth carrying mineral material. The action of the skimming bar and the after treatment referred to here of the concentrate and air bubble mixture are all in accord with that idea. They are not in accord with the idea that we would have here a compact layer of oil carrying in it mineral particles held up by buoyancy flotation, and not connected with froth formation.

I also would like to call attention, before finishing this matter, to claim No. 1 of the Kirby patent In claim No. 1 of the Kirby patent we have in line 14: "First, violently agitating the mass so as to break up said distillable substance"—meaning the thin hydro-carbon liquid—"into minute globules." Kirby does not say that air is entrained, but I do not see that we can escape that conclusion, if we remember the Kirby form of apparatus and the words "violent agitation." The next following in this claim, "in allowing said mass to settle." That is a step—"whereby a considerable quantity of mineral particles, having become coated with said substance, will float to the top of the mass." Now, that ends the first step, the production of the aerated froth by agitation, the allowing it to come to rest, the separating and rising of the froth as described here, which has become coated—"the mineral particles having become coated
3677 with said substance," meaning the hydro-carbon, will float by reason of the air bubbles to the top of the mass. "And in gently agitating the portion thereof which settles." That gentle agitation is to stir up the portion on the bottom, which is a counterpart of the retreatment of the tailings, in which a certain amount has dropped, and the blowing into the same of a gas for the purpose there stated, of assisting the flotation of said substance; that which is on the bottom—and the mineral particles coated therewith. And then, finally, removing the floating layer.

I would just say, finally, in connection with this Kirby matter, that in my opinion the Kirby process, using from 25 to 75 per cent of a light oil for the production of a mineralized froth, accords entirely with the theory of froth production as I understand it, and as it has been testified to in this trial. The thin hydro-carbon or kerosene, which we will take as an illustration of that, is not of itself one of the class of the particularly frothing oils; it is not one of the class that is so characterized, because of its practical insolubility in water, and its inability to sufficiently increase the viscosity of the air bubble film of and by itself. But, when you add the ore pulp and produce violent agitation in contact with the thin ore pulp, you get a permanent froth, because the sulphide mineral concentrating in the oil film gives the needed viscosity to the film, and the result is a permanent mineralized froth. The kerosene, whether used as

25% or 75%, contributes the oil film with some concentra-
3678 tion in the film, which, when stabilized by the mineral particles, gives us a stable froth in every case, no matter what the proportion of the oil is.

Q. 223. You observed the experiment performed by Mr. Dosenbach, representative of the Kirby patent, did you not?

A. I did.

Q. 224. I presume you can not carry the details all in mind, therefore I refer you to Mr. Dosenbach's description. Part of the description appears on page 1224, extending a little onto 1225, and the rest of it appears on page 1227 of the typewritten transcript. I wish you would just examine the details of that experiment, and state whether that represents what he did, and how it accords with your view of the Kirby Process.

A. I have refreshed my memory by reading the description. I saw the operation carried out, and recall the results. In this case 25% of kerosene distillate was used, which represents the thin distillable hydrocarbon that the Kirby patent speaks of. It was carried out in a glass jar with the rotating mechanism, which in my opinion is the counterpart, the equivalent of the apparatus figured in the Kirby patent. Kirby prescribes violent agitation; it is mentioned in three of his claims in those words, and in the specifications he speaks of thoroughly agitating for the purpose of effecting thor-
ough admixture. I therefore believe that we had a per-
3679 fectly fair practice of that Kirby first step in using that apparatus which was used here in the experiment. The amount of oil was taken as stated by him, the character of the oil was that stated by him and the operation was carried out to the end of that first step, with a view of seeing what result was obtained in that first step. The whole of the Kirby machine was not set up, and the practice of the secondary step of trying to recover more of the mineral from the gangue in which it was inclosed and from which it had not been originally raised in the froth—That was not practiced because it did not throw any light at all upon the single question at issue, as to whether a froth is produced in the Kirby process, and if so, what is the character of that froth. I saw the operation carried out, and I recognized, as stated here, the result: "A copious, highly mineralized froth is formed."

Q. 225. The patent in suit refers to the two Cattermole patents. Will you state your understanding of the Cattermole patent No. 777,273, and the relation between that process and the process of the patent in suit?

Mr. Williams: Page 714 of the Hyde record.

A. I have before me the patent No. 777,273, to Arthur Edward Cattermole. In this Cattermole patent we have the following statement, beginning line 16 on page 1: "The invention depends upon the application of the following facts: First, when a mixture
of powdered metalliferous matter and gangue is treated with
3680 oil suspended in water,—that is to say in emulsion;—the oil has a more or less selective action, and will coat the particles

of metalliferous matter in preference to the particles of gangue, while the particles of gangue will be wetted by the water." That statement of fact was quite well known, and had been disclosed originally by Haynes, and afterwards referred to by Everson, and is also disclosed by Froment; that is this selective action of the oil for the metalliferous particles and the coating of the metalliferous particles in preference to the particles of gangue. That is all that has to be considered for the moment.

Now, the second statement of facts on which the invention depends is as follows: "If the water which is mixed with the oil is acidulated, with mineral, fatty, or other acid, the selective action of the oil will thereby be rendered more marked and decisive." That was stated very clearly in the Everson patent, and Dr. Liebmann has testified that Everson contributed the feature to the art, that acid aided in the selective action of the oil.

The third statement of fact is as follows: "If the proportion of oil is kept within reasonably low limits, (differing in different cases according to the nature of the mineral to be treated and the consistency and nature of the oil), and if the mixture of water, oil, metalliferous particles and gangue be thoroughly agitated, the metalliferous particles that have become coated with oil will
3681 adhere together and form granules, which granules, partly by reason of gravity or partly on account of their bulk as compared with the individual grains of gangue, will offer ready means for separation in an up-current separator, a jig or other similar appliance." This statement of fact, if considered broadly and with reference solely to the proportion of oil, is not a correct statement, because I have seen in the course of this trial the production of an excellent mineralized froth by the carrying out of agitation in the form of apparatus as shown here, with the Gabbet cone mixer, using a relatively larger amount of oil, which has been considered as the Cattermole proportion, or within the Cattermole limit. That granules can be formed, of course, is true, but I do not consider that the formation of the Cattermole granules is dependent solely or even mainly upon the statement of the proportion of oil, that the proportion of oil is to be kept within certain limits. The experiment which was carried out by Mr. Dosenbach and which was witnessed by me, showed plainly that the production of the Cattermole granules was dependent upon certain conditions of operation, and not upon agitation in the presence of a certain particular amount of oil. The first result in the carrying out of the experiment was an excellent froth. That was obtained under the conditions of rapid agitation with the Gabbett cone mixer, using baffles in the cylinder. Without removing the baffles it was found possible to break down this
3682 froth, discharge the air from it and produce the aggregation of the mineral particles spoken of as granules, in the same vessel with the same mixture, solely by changing the condition of agitation. Therefore I do not consider that this third statement of fact is true in the way in which it is stated, and I do not consider

that this attributing the formation of the granules to the proportion of oil alone is an accurate statement.

The statement is made further on that this action, meaning the production of the granules under the conditions stated here, is facilitated if the oil, before the addition to the liquid, is brought into a condition of emulsion in water containing a small amount of soap or other emulsifying agent. That, of course, is very likely, but that is simply a facilitating of the action; that does not involve modifying the statements that I have made, that the production of granules is not dependent upon the conditions stated in lines 29 and 30 of this patent.

Q. 226. Can you explain that apparatus which is shown in the Wolf patent No. 787,814, and what its bearing is upon your discussion of these different processes?

A. The Wolfe patent, No. 787,814——

Mr. Williams: Complainant's record Volume 3, page 966.

The Witness: The Wolfe patent, dated April 18th, 1905, has some considerable interest, because it shows clearly an efficient
3683 aerating mechanism—an agitating and aerating mechanism for the mixture of oil and a thin air pulp in connection with a spitzkasten, and the obvious intent and plan, as described in the patent also, is the production of a froth in the first vessel shown, and the drawing off of that froth through a short launder or connecting tube at once from the top of the water in the spitzkasten, where it flows, as stated; while, on the other hand, the gangue sinks and is drawn off from the bottom of the spitzkasten, and the flow is further carried then through a side connection from the upper level in the spitzkasten. This connection of the froth producing mechanism and the spitzkasten is interesting as shown at this day. I refer in the patent to the description on page 1, beginning line 61: "The mixture of oil and pulp passes into the hollow cylinder B^1 and the rotation of the turbine wheel, B2, causes a rapid circulation of the mixture downward within the cylinder, and upward between the cylinder and the vessel B." Stopping there for a moment I wish to recall that I have already stated in connection with this construction, when I referred before to the Wolfe patent, that Mr. Sulman had stated in his testimony in this record that this was a very efficient apparatus for producing aeration results, because of the construction of that hollow cylinder, which caused it to act as a baffle, and he considered it to be a very efficient baffle for the purpose of preventing continuous rotation within the circular walls of the cylinder.

3684 In line 66, page 1, we have the further statement: "The liquid is continuously discharged from the mixer through the pipe B5, and passes into the separating tank or spitzkasten, and here the sulpho-chlorinated oil adhering to the mineral of the ore, floats while the gangue remaining in admixture with the water sinks and is removed by the waste pipe C^1." I also find further down on page 1, line 92, the following statement: "By the means thus provided for eliminating the gangue it is possible to treat ores with such a degree of agitation that the whole of the mineral contents are

taken up by the oil, accompanied, however, by a not inconsiderable portion of gangue." That is a result which happens in practice constantly and involved retreatment and repeated retreatment to get out of the first tailing the valuable mineral which was not floated in the primary cell.

Wolfe, in this patent, believes that he can remove the gangue which is there by a hot water treatment. We are not particularly concerned with that, because it is not a matter which in my view has any bearing upon the patent in suit; but I only refer to this Wolfe patent for the purpose of calling attention to the action of the apparatus and the type of the apparatus, as an efficient agitating aerating device combined directly with a spitzkasten, and for a purpose which is indicated very satisfactorily when we come to the claim.

3685 I would call attention to claims 3, 4, 5 and 6 of this Wolfe patent, in which we have the reference to agitation and the reference to separation of the mineral-bearing oil from the pulp, and flotation. The word flotation appears there as the separation method; that appears in four of the claims "Separating the mineral-bearing oil from the pulp by flotation." After having effected a vigorous agitation with an efficient form of aerating apparatus.

Now, I feel satisfied that we can not practice this procedure of first practising agitation with that form of apparatus, without producing an aerated froth, which holds the mineral, as stated, quite completely, and then if we follow that by a flotation as described here in these claims of the mineral-bearing oil, an air bubble mixture over the top of the spitzkasten, that it is impossible to have anything else than the removal of a mineral-bearing froth.

Q. 227. Doctor, you called attention the other day to the fact that in Froment's Italian patent the expression used in the complete specification of the British patent, that the invention is a modification of what is known as the oil process of ore concentration, was not used—that this expression was not in the Italian patent. Will you tell whether this expression is in the provisional specification of the British patent, and state also, if you have information, what the relation of the provisional specification is to a complete specification.

3686 A. On looking at these patents I find that there is no word at all in the Italian patent, either in the French or the English translation given here, of that matter, of its having any relation to a previously known oil process. When we turn to the English patent, we find the provisional specification, which was the more immediate contribution of the inventor, I imagine, or, as I understand it, to the patent agent, contains no reference to this connection or supposed connection. The statement in the British patent that it is in any way related to a previous process, only appears finally when we come to the complete specification, which stands in the name of Henry Harris Lake, the patent solicitor, and that is as follows: "This invention has reference to the concentration of metalliferous ores and earths for the purpose of separating and recovering therefrom the finely divided metal or metallic compounds, and consists of a modification of what is known as the oil process of ore concentration." That was a gratuitous addition made finally in the

complete specification in the English patent. It does not appear anywhere in the Italian patent, and appears only in this last statement in the English patent, and it has not justification, to my mind, from anything that is found in the patent, English or Italian.

Mr. Scott: I offer the British patent referred to, No. 10929, of 1910, to Theodore Jesse Hoover and Minerals Separation Ltd., this being the patent to which Dr. Sadtler referred as containing a statement that the Froment process produced a froth.

The Court: That is not in the Hyde record?

3687 Mr. Scott: No, sir; it is an additional one.

Mr. Williams: In view of the fact that it was in the Miami record and I know all about it, I have no objection.

Patent No. 10929 admitted in evidence without objection, marked Defendant's Exhibit No. 216.

Mr. Scott: I offer a drawing illustrating a picture of the Fryer Hill machine which was admitted in evidence as one of defendant's exhibits.

Drawing admitted in evidence and marked Defendant's Exhibit 217.

Mr. Scott: You may cross examine.

Cross-examination.

By Mr. Williams:

I would call your attention, Mr. Scott, to the fact that the witness referred to a number of patents in his testimony,—and one of them was patent 962,678.

Mr. Scott: I will offer that to make the record complete. I offer patent 962,678 of Sulman, Greenway and Higgins.

Patent admitted in evidence and marked Defendant's Exhibit 218.

3688 Mr. Williams:

X Q. 228. Did you testify as follows in the suit of Minerals Separation, Limited, against Miami Copper Company, relative to the Fryer Hill publication:

"X Q. 667. Then you got your thorough agitation out of the Everson patent?

"A. I took that from the Everson patent.

"X Q. 668. There is not anything here which defines the nature of agitation to your mind?

"A. The only statement I find here is: 'Arastralike fans, attached to the bottom of the tube, keep the whole mixture in motion.' That is a very vague statement, and it is not at all as definite as the statement in the patent.

"X Q. 669. Well, now, this Fryer Hill publication contains no directions as to the quantity or proportion of oil to be used—is that right?

"A. That is right. Those have been taken from the patent.

"X Q. 670. It contains no directions as to the kind of agitation to be used—speed of agitation?

"A. No, it does not.

"X Q. 671. And is not associated with any directions representing any definite mechanical structure?

"A. There are none.

"X Q. 672. It contains repeated statements about mineral la len oil, mineral charged oil; that is right, is it not?

"A. There are several statements.

3689 "X Q. 673. And yet you will take this article as the basis of a representation in this court that this machine, operating at about 2,000 revolutions per minute, is the machine there describe l, and that the operation produced in that machine is the operation there described—is that the situation?

"A. I have explained in previous answers that from the dates of this publication, and the publication immediately following it, in which latter publication reference is made by name to the Everson process, and then the fact that the general, very vague outline of this newspaper article is entirely compatible or in accord with what could be done. Following more accurately the directions of the patent, I have been led to consider that it is a description of the experiments carried out in the way of developing the Everson patent."

Did you so testify?

A. I think probably you have read that correctly.

Mr. Scott: Do you wish to compare it, doctor? If you do, you may compare it with this testimony that has been read to you.

Mr. Williams: I have read it with the greatest care. I would like to know whether I have read it correctly.

A. You marked the beginning and the end of it?

X Q. 229. Yes.

A. And the ending of it is here?

X Q. 230. Down here.

The Court: The better way then would be for the witness to have a copy and follow it.

3690 Mr. Williams: I am sorry that the time should have been wasted. The witness has a copy of it. I thought he had it right here and I wasn't paying particular attention.

The Court: Oh, I think he can say that you read it correctly. He will have the privilege of checking it up.

The Witness: I think I answered correctly those questions at that time. I think the answers as stated by you were the answers given at that time.

Mr. Williams: I want the witness to answer the question that I have read it correctly with the understanding that he may correct my reading if I have made any mistake.

A. I believe it has been correctly read.

Mr. Williams: I will read it over again and you will follow me.

Mr. Scott: The doctor admits you read it correctly, Mr. Williams.
Mr. Williams: Page 1081, volume 2, Miami record.

(Whereupon counsel read the extract from the witness' testimony in the Miami case as previously quoted.)

Have I read that correctly?
A. You have. Mr. Williams, do you wish me to say whether I agree with the statement of the view I there expressed?
Mr. Williams: I don't care for that now.
A. All right.
3691 X Q. 231. Now, turn to page 1083 of that volume commencing at question 687. I will read the following, and ask you to follow it:
"X Q. 687. Now, you have referred to the Criley and Everson publication, appearing on page 393 (Ex. Book, p. 17). Now, in that we have the distinct statement that the oil used was a black thick oil? You know that, do you not?
"A. I do.
"X Q. 688. You have not carried that out, have you?
"A. I have not.
"X Q. 689. You were asked to consider this publication in question, and you appeared to pay no particular attention to it in your answer. Do you regard, as a disclosure of a metallurgical operation, capable of being carried out, what is there disclosed?
"A. It does not, as a disclosure, give enough details to make it possible to carry it out in a definite and accurate way. It leaves entirely too much to chance.
"X Q. 690. Will you accept what the Privy Counsel said about the Criley and Everson publication? (Ex. Book, p. 209?) Even if the test process is not to be discarded as a failure, it does no more than give information "that if to a greased mixture of pulverized metal and rock you add boiling sulphuric acid in a sufficient quantity of water in some way a differentiation is effected as between the metal and the gangue." That is quite as complete a statement as is given in this publication. It is a very fragmentary statement. Will
3692 you accept that as a proper description of the extent of the disclosure?
"A. No; I would not accept it for that reason.
"X Q. 691. You will not agree with the Privy Council?
"A. No."
Have I correctly read your testimony in the Miami case?
A. You have, yes.
X Q. 232. Are you familiar with the definition of an arastra?
A. I have heard it fully explained and it is in the illustration.
X Q. 233. Have you seen the illustration in the Century Dictionary?
A. Yes.
X Q. 234. Representing a vertical arrangement with stones, dragged around by a team of mules, traveling around and dragging it?

A. Yes.

Whereupon an adjournment was taken until 2:00 o'clock p. m.

2 o'clock p. m., May 3d, 1917.

X Q. 235. Relative to the references that you have made to Ure's Dictionary of Arts, Manufactures and Mines, the first of these references was to an illustration on page 332, described on pages 331 and 332. The apparatus is shown in Fig. 1379, and was given by you as an example of a spitzkasten, was it not?

3693 A. Yes, as a separating vessel.

X Q. 236. And I understand that you said it was a classifier?

A. I don't recall whether I used that expression or not.

X Q. 237. The description of this appliance says that it is a separating box, which receives slime water, and that the heaviest portion is discharged at the bottom and goes to the buddles or shaking tables. That is correct, is it not?

A. That is so stated.

X Q. 238. Do you know what a classifier is in ore concentration?

A. I don't know in any accurate way; I only know that the principle is that of allowing the heavier particles to separate, and the lighter ones to pass on and pass relatively successively in the order of their gravity.

X Q. 239. And as a matter of fact, in a classifier it is the order of the sinking power in water rather than gravity which controls, is it not?

A. The sinking power of the materials in water, yes.

X Q. 240. Now, the illustration on page 335, this is also a slime separator, is it not?

A. It is spoken of as a form separator, in which the compartments shown, numbers 1, 2, 3 and 4, are to serve for the purpose of receiving minerals of different densities and size, and they deposit successively according to their density as carried along by the

3694 stream of water. That would be, I presume, a classifier, although I do not use the term in any technical sense.

X Q. 241. On pages 356 and 357 the apparatus shown in Fig. 1419 is described as a dolly tub, or packing kieve. Do you know what that means?

A. Well, I read the description, and I understand what is to be accomplished in this particular use here described of this apparatus. I did not intend to cite the apparatus as one which would be used for that purpose, but as a form of apparatus which, removing that detachable lid, was perfectly adapted for serving as an agitation vessel which would necessarily, if rapidly rotated, entrain air. It was offered for that purpose, for illustration.

X Q. 242. And in the description it says that as the handle is turned by two men, slime is shoveled into the top. You knew that, did you not?

A. I read the description as given here. It is illustrated as oper-

ated by hand power, and a couple of men are spoken of as taking hold of the handle and turning it rapidly. It is very obvious to me that it is just as capable of being rotated more rapidly by a power connection with the aid of a pulley. It does not affect the purpose for which I introduced it, which was to call attention to the form of agitation which would be accomplished by these paddles.

X Q. 243. Figure 1420 shows the condition at the completion of the operation with the various strata of solid material as they separate, does it not?

3695 A. It does.

X Q. 244. Referring now to the translation of the work of Agricola I read from the test the description of the apparatus which is shown in the photograph, defendant's exhibit 51. I read this description as follows: "Quicksilver is placed in each tub, across which is fixed a small plank, and through a hole in the middle of each plank there passes a small upright axle, which is enlarged above the plate to prevent it dropping into the tub lower than it should. At the lower end of the axle, three sets of paddles intersect, each made from two little boards fixed to the axle opposite each other. The upper end of this axle has a pinion held by a bearing set in a beam, and around each of these axles is a small drum made of rundles, each of which is turned by a small tooth drum on a horizontal axle, one end of which is mortised into the large horizontal axle, and the other end is held in a flat cup with thick iron plates in a beam. Thus the paddles, of which there are three sets in each tub, turn round and agitate the powder, thoroughly mixed with water and separate the minute particles of gold from it and these are attracted by the quicksilver and purified. The water carries away the waste." Have I read that description properly?

A. You read it accurately, yes, sir.

X Q. 245. Relative to the first method disclosed in the Everson patent, you testified in the Miami suit as follows, did you not, page 1059, X Q. 502, "It did not seem promising from a metallurgical standpoint as an operation? A. No, sir. X Q. 503. And

3696 you have not done it? A. No, sir." You so testified, did you not?

A. I did so testify in regard to the first illustration of the Everson patent.

X Q. 246. Referring now to your testimony in the Miami suit, page 1067, where you were asked on X Q. 553 what devices and methods were well known in the art in the wet separation of ores in 1886 you answered: "A. The spitzkasten, or its equivalent, was known and available in that case, or if not by name, its equivalent in the form of some overflow vessel. X Q. 554. Was there not another device used in the wet separation of ores which was peculiarly adapted for washing out by a complete overflow, to-wit, the water classification apparatus? A. I explained in my testimony yesterday that I was not a metallurgical engineer, and therefore I must decline to say what was known at that time, of wet concentration methods, because I have not studied that." Did you so testify in the Miami case?

A. I did so testify at that time.

X Q. 247. Referring again to your testimony in the Miami case, page 1056, relative to what you had done in that case as to the carrying out of the Everson patent and the Fryer Hill publication, did you not testify as follows: "X Q. 477. What you have done, as I understand, is to take the proportions of oil which are described in the patent, and you have done things with them? A. Yes, sir." So far as I have read that is accurate is it not?

3697 A. That is correct.

X Q. 248. I did not add the final part of the answer because I did not think it adds to the explanation. Now, relative to the description of Froment as a froth which you say you found in certain British patents and particularly British patent No. 23,870 of 1910, I refer you to that patent which is at page 1005—commencing at 1001.

A. The British or the Italian?

X Q. 249. No, the Minerals Separation, Limited, and Nutter patent 23,870 of 1910. That appears in the Hyde record, complainant's record, volume 3, page 1001. I first refer you to page 1003 which is page 3 of the specification at the commencement of the complete specifications. In the last paragraph there is a general reference, is there not, to processes described in previous patents including the British patent corresponding to the patent in suit and the British patent corresponding to the solution patent?

A. If you can give me the page and line of the patent I can find it.

X Q. 250. The last paragraph of page 3 of the specifications, page 1003 of the record. And this statement does not include the Froment patent, is that correct?

A. The statement at that point does not include it but in that same complete specification it is included at the point at which I quoted, in the same complete specification.

X Q. 251. I didn't ask you that.

3698 A. It is not included at this point.

X Q. 252. Now, the point to which you call attention was on page 5 of the specifications as I recall it?

A. Yes.

X Q. 253. Lines 22 to 24, is that right?

A. That is right.

X Q. 254. And the patent states: "The process employed to obtain these froths or scums may be any of the well known flotation processes as described for example in patent No. 12778, 1902; 29374 of 1904, 7803 of 1905, and two others and this 2359 of 1909.

A. That is what I quoted.

The Court: Now, I want to understand this clearly. This speaks of producing froth and scum, and then says it may be any of the well known flotation processes, and names amongst others, the Froment patent; is that right?

Mr. Williams: Yes, sir, having become well known by reason of

the fact that it was patented, and that the patent was widely published.

X Q. 255. Now, I call your attention to the fact that on page 3 of the patent wherein the Froment patent is omitted, the reference is to processes—"that have hitherto been used in the practice of the separation of metallic sulphides from gangue." That is true, isn't it?

A. Let me read that. It is true that the processes which are there enumerated are spoken of as hitherto used for that specific purpose, of separating metallic sulphides from gangue, and they proceed then to particularize as to their new application of the flotation
3699 processes, a separation between metallic sulphides, which was the point of the invention, and for that reason they quoted these prior patents.

X Q. 256. Now, let us turn to the California Journal of Technology, commencing on page 681, exhibit 47. The first part of this article, up to the point where a reference is made to the foam effect, is devoted entirely to the Elmore oil buoyancy flotation process, is it not?

A. Down to the heading "Laboratory Methods." That part which precedes that is devoted to the account of the Elmore process, and particularly with reference to the question of the supposed further development of it by means of a centrifugal separator. That carries us down to the heading "Laboratory Methods."

X Q. 257. Now, in the part of the description preceding that heading, and the particular description of the Elmore commercial apparatus illustrated on the first page of the article—that is the Elmore commercial apparatus is it not?

A. I presume it is. It is referred to there as a plant designed by the Oil Concentration Syndicate. I don't know anything at all about the connection that that particular syndicate may have with the Elmore process, but it is undoubtedly referring to the Elmore process.

X Q. 258. Don't you recognize that as substantially the apparatus that is shown in the Elmore first patent?

A. I can not be quite certain about that, but I am willing to say that it carries out the Elmore procedure in accordance with the spirit of the Elmore process.

3700 X Q. 259. I now show you the drawing of the Elmore patent, the first process patent, No. 676,679, and ask you whether or not the drawing in this California Journal does not show in substance the same apparatus.

A. It shows the same general plan of operating.

X Q. 260. In reading over this description I find the following: "The mineral laden oil, collected from the separators, is carried to a large receiving tank, B. Here, after being heated, in order to thin it and to overcome its viscosity, the oil is charged into centrifugal machines, where the concentrates are separated out. The oil, free from its load of mineral, is pumped back to the original storage tank to be used again." That is correct, is it not?

A. That is correct.

X Q. 261. The expression "mineral laden oil" is an apt expression to describe the Elmore float?

A. That is the expression which refers to the way in which the mineral is carried in the Elmore heavy residuum oil.

X Q. 262. And in the Elmore process heat is not used in the process because it impairs the viscosity of the oil, is that true?

A. Not up to this stage.

X Q. 263. Not until the separation is completed?

A. Until the mineral has gone into the oil.

X Q. 264. The mineral has gone into the oil and the float has been overflowed, and after the float has gone into the receiving tank.

A. I don't know anything about the float; I don't know
3701 just how you apply that term in that case, but following the illustration here, the separation of the compact oil layer from the water has taken place, and the mineral is carried in that upper oil layer.

X Q. 265. And then this description says that the mineral laden oil goes into the receiving tank B, and there heat is applied, does it not?

A. After that, in order to advantageously centrifugate.

X Q. 266. And also to overcome the viscosity of the oil, that is the language?

A. That is the purpose, yes.

X Q. 267. And in the process up to the point of the separation, heat must be avoided, must it not?

A. In the Elmore process.

X Q. 268. Then this description speaks of the oil as a heavy residuum, does it not?

A. It does.

X Q. 269. And says usually about a ton of oil is kept in operation for each ton of ore, does it not?

A. Yes, usually about one ton of oil.

X Q. 270. And then it speaks of an advantageous method of separation, whereby "the losses are not greater than from one to three gallons of oil per ton of ore." That is correct, is it not?

A. That seems to apply to this carrying out of the Elmore process, with the steps mentioned, that of thinning it by heat and centrifugate it, and in that way they reduce the relative loss of oil.

X Q. 271. What is the measure in pounds of one to three gallons of heavy residuum oil, per ton of ore?

3702 A. The specific gravity of the oil is given there as .9, so 100 pounds of that would be 90 lbs.—that is, you would have 90 lbs. indicated there as the weight of a volume corresponding to the volume of the ore.

X Q. 272. From one to three gallons of oil per ton of ore would be how many pounds of oil per ton of ore?

A. Well, I don't know whether I can calculate that off-hand. I don't know the weight of a gallon off-hand, of liquid of a gravity of .9. I could find it in the table.

X Q. 273. Well, never mind, I will supply the calculation; I thought you had it in your head.

A. No. I can give you the figure any time that I can take the tables and calculate it.

X Q. 274. Now, let us turn to the tests to which you have particularly called attention, under the heading, "Test, Molybdenite Ores." Now, the first item which you did not read was the mesh, 30. That is very coarse material is it not, for flotation treatment?

A. The ore here is given in these experiments as 30 mesh in the experiment in which the small quantity of oil was used.

X Q. 275. And I read the part of the description which you did not read, which refers to Nos. 1, 2 and 3, evidently to the Elmore oil buoyancy experiment, but which is followed by the description of the smaller proportion of oil experiments. "Experiment No. 1 showed the presence of middlings, requiring finer crushing to liberate the sulphide."

3703 A. That was 20 mesh.

X Q. 276. Therefore that was too coarse for use?

A. For that purpose.

X Q. 277. "Experiment No. 2 and No. 3 gave practically the same percentage of extraction, but the concentrate in No. 3 was much lower grade than in No. 2." Now, No. 2 was the 30 mesh; that was a little finer, wasn't it?

A. Thirty mesh is finer than the first one, 20 mesh.

X Q. 278. And No. 3 was 40 mesh?

A. Yes.

X Q. 279. Now, when they go to forty mesh it says the grade of concentrates was much lower than it was in No. 2. That is to say when they lower to forty mesh they get a lower grade of concentrate? That is it, is it not?

A. But they change the amount of oil between two and three. There is another element comes in.

X Q. 280. Yes, but it is only one and two thousand k. g.—2,000 gms.?

A. Just as it is given there in the other case.

X Q. 281. And the amount of ore was 1,000 gms. in the number 3 and the amount of oil is just a little more than that, about 1,200 gms.?

A. 1,200, yes, there is a difference in the two.

X Q. 282. There is a little difference in oil. That is to say, the proportion of oil to ore is slightly increased as 1,000 is to 1,200? Is that right?

A. That is the difference between those two.

X Q. 283. Then it says "A comparison of values of concentrate in number 1, number 2 and number 3 shows clearly that 3704 although the finer crushing has freed the molybdenite sulphide from the gangue, at the same time it has produced a larger percentage of fine gangue which, becoming mechanically occluded, in the oil, gives a low grade concentrate." I have read it correctly, have I not?

A. That is correctly stated.

X Q. 284. Now, following that were experiments Nos. 4, 5 and 6, which it is said "show the results obtained by treating separate samples with small quantities of oil in a salt solution, and agitating violently to produce the foam effect." I have read that correctly, have I not?

A. That is correct.

X Q. 285. "This method gives the highest grade concentrates of any of the direct treatments here outlined. In experiment number 6 only about 10 cc. of oil was used for 100 gms. of ore. This gave an extraction of 75 per cent with concentrates running 32.4 per cent molybdenum sulphide." The experiments which gave the best extraction or the best record was the last of these three with 8.9 per cent of oil, was it not?

A. Yes, sir.

X Q. 286. And the experiment which gave the poorest extraction or recovery was the one in which 2.1 per cent of oil was used, is that right?

A. It is in that report.

X Q. 287. And the recovery there was 43.5 per cent, and when the amount of oil was increased to 5.3 per cent the recovery
3705 was 47 per cent; and when the oil was increased to 8.9 per cent, the recovery was 75 per cent. That is correct, is it not?

A. I think something must be borne in mind, to-wit, the number of treatments indicated there.

X Q. 288. Yes. You didn't explain that. Suppose you explain it?

A. I think that that indicates that there was a second treatment and a third treatment.

X Q. 289. That is after the manner of the Elmore process, when you put the things through a centrifugal and thereby extract the oil and then send it through again, isn't that so?

A. This has nothing to do with the Elmore process whatever; there is no connection with centrifugation here. It is the foam effect. The foam effect is not centrifugation.

X Q. 290. I call your attention to the fact that that column headed "Number of treatments" runs through the upper three experiments, which are Elmore experiments, and there we have number of treatments four, number of treatments three, number of treatments three, so you know what they mean is the Elmore process, don't you?

A. No, I can't say that I do.

X Q. 291. Well, it is described in this article, professor, that they put them through the centrifugal and used it over again?

A. Under it, by the use of a series of cylinders. But the
3706 application of the Elmore method under the head of additional treatment is not possible where we are trying a foam effect. The foam effect is tried and shown there and described by these writers and it has no possible application to a second or third following of the Elmore; haven't anything to do with it, not the slightest.

X Q. 292. I don't think you have figured that out, Professor?

A. I have not figured out what this "treatment" means because it is not indicated, it is not indicated at all, and therefore I am not

prepared to say that that has one value or the other, but I am prepared to say that whatever it is it is not a following of any step of centrifugation or anything else of the Elmore process. That is practically out of the question with the foam method of operation.

X Q. 293. Now, everything that we have been considering in this table is under the heading "Laboratory methods," isn't it?

A. No, the heading in the case of tests, laboratory methods describe what was found on page 36 of this California publication, laboratory method applies to what there follows: "The mixing or agitating can be done in two different ways. The charge may be agitated very gently, the oil being kept in a single lake, and broken up as little as possible, consistent with a thorough contact of pulp and oil, or the charge may be agitated so violently as to dash the oil up into a foam or froth full of air bubbles, thus a very thorough contact of oil and pulp is obtained. Each method has its
3707 advantages and disadvantages, and these are discussed later."

Now, this is what is implied when he begins the discussion of laboratory methods and the way in which this laboratory—these laboratory methods are carried out is farther described on the same page, page 36: "Three methods of mixing may be used. 1. By inverting the tube several times, thus allowing the ore to fall through the oil. 2. By rotating the tube in a horizontal position, thus throwing the pulp upon the surface of the lake of oil. 3. By violently shaking the tube, thus producing the foam effect, or at least shattering the oil into small globules." Then after that we come to the tests. These tests are not necessary any longer to be considered as illustrative of these laboratory methods, but they are the application of the laboratory method to particular tests of ore for the purpose of arriving at a knowledge of results.

X Q. 294. Now, just read the first paragraph there, that headed "tests"—molybdenite ore. Read it aloud.

A. "The ore treated was low grade——" that is what you mean?

X Q. 295. Yes, read that paragraph?

A. "The ore treated was low grade with the values fairly disseminated. The gangue minerals were orthoclase and quartz. Samples were crushed to 20, 30 and 40 mesh, and treated in percolating tubes as outlined above. The details and results are given in the following table."

X Q. 296. Don't that make it pretty clear that these were laboratory methods?

3708 A. In the sense that they were small operations, of course they were laboratory methods; but now applied in a quantitative application. The distinction I make is not as between small scale operations and mill operations. That is not my distinction. My distinction is as between the figures which I described. "Methods of operation" as here discussed in this operation are specific tests, and here are some of these.

X Q. 297. Now, is it not a fact that the only operation described in that table and described there as a laboratory method in the percolating tube carried out with less than 100 per cent of oil and

showing a recovery that has any metallurgical value is the operation with 8.9 per cent of oil to the ore?

Mr. Scott: That certainly is objected to. The doctor has just testified that this was not necessarily a laboratory method, and the question contains the statement that it is.

The Court: Well, that different application of terms is all. I think he will not mislead the witness. I cannot drive the doctor to accept his terms or he is not to be driven to accept the doctor's terms.

Mr. Williams: I want to shorten up, your honor.

A. I have granted that these tests were carried out in percolating tubes as stated specifically. I don't call that laboratory methods, but the application of laboratory methods in practice as such on a small scale, but still quantitative because the matter was followed
3709 out with care in the weighing and followed out with care in the examination of the concentrate, in the molybdenum sulphide which you will note runs higher in experiments 4, 5 and 6, than in experiments 1, 2 and 3, and that is the one case we get the maximum percentage of extraction. In the case of experiment 6 also were small scale experiments carried out in percolator tubes and they represent the application of laboratory method in practice.

X Q. 298. You have not answered the latter part of the question. Please read the question.

(Question read as follows: "Now, isn't it a fact that the only operation described in that table and described there as a laboratory method in the percolating tube carried out with less than 100 per cent of oil and showing a recovery that has any metallurgical value is the operation with 8.9 per cent of oil to the ore?")

Mr. Williams: The question whether that is not the only one of these less than one hundred per cent operations which shows a recovery having any metallurgical value?

A. I am not prepared to say that was a recovery of metallurgical value because the statement follows immediately after that that these retreatments were not merchantable, but would have to be reconcentrated; but it represents the highest figure in percentage of extraction and the figure is also higher as I say in the value of concentrate, that is molybdenum sulphide, than those of the earlier ones. I can't characterize it any more exactly than that.

3710 X Q. 299. That is to say in that you only lose 25 per cent of your metal in the operation while in the other two you lose respectively 53 per cent and 56.5 per cent, that is right, is it not?

A. In this first concentrate product those are the figures and the other amounts that you have mentioned are yet to be recovered by retreatment, as specially stated by the authors.

X Q. 300. And as you read it in experiment 5 there has been a retreatment of the original and with retreatment the recovery has been 47 per cent, is that right?

A. I am not able to say what that means as to the number of treatments. It possibly was not what he called reconcentration.

X Q. 301. You do not know what it means?

A. I do not know what it means. That is correct.

X Q. 302. And then down near the bottom of the page, as you have the article in the fourth page, following the table, we have a description, have we not, of a No. 9 concentrate having been brought up to fifty per cent of molybdenum sulphide?

A. That is reconcentration; that is bringing from—32.4 up to 50.02.

X Q. 303. And apparently that was the climax of the operation that these students performed.

A. That is as far as they reported it.

X Q. 304. Now, following this description of the test with molybdenite ore we have a description of tests with copper ore, have we not?

3711 A. Yes, sir.

X Q. 305. And no mention of anything less than substantially Elmore oil buoyancy proportions, is that right?

A. We have mention of 1.2 k. g., which means 1200 gms., treated there in a large percolating tube with 500 cc. of oil which is less than the Elmore amount.

X Q. 306. And then it states that it was gently agitated for twenty minutes, doesn't it?

A. Yes.

X Q. 307. So that must have been an Elmore process, must it not?

A. I can't say. The amount of oil was not sufficient for Elmore. I don't know what he means by "gently agitated in a percolating tube."

X Q. 308. So you think that might be a foam effect?

A. It is some form of agitation.

X Q. 309. You don't find any description which you can identify as a foam effect, do you, under this heading of copper ores?

A. No, sir.

X Q. 310. Nor under the heading of gold ores, do you?

A. I believe not.

X Q. 311. Now, in conclusion, on the last page of the article, the statement is, is it not, that the oil was thrown into a froth which was heavily charged with air or other gas?

A. That is correct.

3712 X Q. 312. And then follows the statement that this gas of course gives a greatly increased buoyant force. That is right?

A. That refers to the bubbles so obtained. The bubbles of gas have greater increased buoyant effect.

X Q. 313. Then it says the oil in this condition assumes a certain load of mineral and holds it in a very stable condition. That is right, is it not?

A. Yes, that is this froth condition.

X Q. 314. And further it says, "The charge does not settle and overload on standing" and describes the result of the operation?

A. Will you finish that sentence if you please?

X Q. 315. "As is the case of the lake effect."

A. Yes, there is the distinction made. There is no overload here in the froth effect as there was in the lake effect.

X Q. 316. What is overloading in the lake effect?

A. The gradual dropping away of the mineral particles from the layer of oil in which they have been first taken, and on standing that frequently is said to result, but by reason of the insufficient buoyant power of the oil or with any little disturbing of the compact layer of oil, this overloading becomes imminent and a dropping out of the mineral takes place.

X Q. 317. And, as a matter of fact, the mineral and oil together drop out, don't they, the oil being overloaded and not buoyant enough to float, the oil then goes with the material.

A. I am not prepared to say how much oil goes with the
3713 material that drops, but it is substantially as described. Ore dropping out of the mineral, it must of course be oiled.

X Q. 318. Haven't you seen these blobs drop down from the Elmore float, here one afternoon?

A. Yes, sir.

X Q. 319. And these blobs are overloaded themselves so that they can't float by buoyancy? That is true, is it not?

A. It is merely because the buoyant effect of the oil does not suffice to hold up the mineral, and in pulling away it drags oil in some degree.

X Q. 320. And that oil and mineral together are not buoyant enough to rise to the surface. That is right?

A. No.

X Q. 321. Now, the conclusion is the foam effect is best adapted for light, flaky mineral such as molybdenite? What is that character of lightness and flakiness which they there refer to?

A. Well, molybdenum crystallizes in flat, flaky crystals, and its cleavage and general structural character is that of a flaky condition; and as they tried the experiment with molybdenite and got results which satisfied them, they have assumed that this was the typical form of mineral adapted for the foam effect. Whether that conclusion would have been modified on a larger amount of experimentation is another question. That was their conclusion as stated here, based on what they had done here.

3714 X Q. 322. Now I will refer you to the record in the Miami suit, page 1183. Did you not in your testimony there in answer to re-cross 1368 characterize what is described in this article in the California Journal of Technology as "that little foam effect" in the California publication?

A. I did so speak of it because the operation was a small operation and the little foam effect was entirely so characterized because it was done in a percolator. There was no intention to distinguish between much or little volume of foam in any such relative way, but the little foam effect referred to the small tube experiment.

X Q. 323. Now, we will turn to the Kirby patent which appears

on page 738 of the Hyde record, and first we will take on page 738 the drawing on the first page.

A. I have the first page of the drawing.

X Q. 324. Now, the apparatus indicated by the letter A is the apparatus described in the specification as the mixing tank is not?

A. Large A, yes, sir.

X Q. 325. And small *a* is the revolving plow described in the specification?

A. Yes.

X Q. 326. Now you said that that curved dotted line above there represents a vortex?

A. I did.

X Q. 327. Do you adhere to the view that that shows a
3715 vortex with an opening shown for the purpose of admitting air to the bottom of the vessel?

A. The reference in the patent to the arrows and what they indicate——

X Q. 328. You have not answered the question. Answer first and then you can explain.

A. I do consider that that curved line illustrates the direction of a vortex.

X Q. 329. Well, that is the whole question.

Mr. Scott: You may explain now, if you wish.

A. I consider that it refers to a vortex, and I think I am justified in taking the two things together, the statements of the patent that the direction of the arrows indicates that there is a current, as stated here—"which result is facilitated by the current as created in the charge by the action of said plows, the direction of said current being indicated by the arrows in Fig. 1." Now, if we have the current established as indicated by the arrows, it is undoubtedly a vortex. I think the appearance of the curved line was an illustration of a vortex, designed to additionally confirm that statement, that there are produced a series of currents which, with rapid rotation means the production of a vortex such as is very easily seen by any of these rapid rotations when in motion, and that means the entraining of air.

Mr. Williams:

X Q. 330. Now, how, according to the specification, is that mixing tank operated; what functions are performed in that mixing tank according to the specification?

3716 A. I find that on page 1, line 68: "First, in thoroughly agitating it together, the pulverized ore or mineral material. B, enough water to make the said pulverized ore a flowing pulp. C, a solution of bitumen in addition to a distillable hydro-carbon liquid, as kerosene. These materials to be so thoroughly agitated together as to finely subdivide said solution into small globules and bring said globules into contact with substantially all of the pulverized mineral particles which will, by preference, adhere to them.

Now, there are statements as to what are the components of the mixture there, statements that we have thorough agitation of the

mixture; statements that the materials are so thoroughly agitated as to be finely subdivided in the solution in small globules.

X Q. 331. What is the solution?

A. The solution, meaning kerosene holding some bitumen in solution.

X Q. 332. That is to say, the oil is broken up into small globules of oil; that is right, isn't it?

A. Yes, then it says, "and bring said globules into contact with substantially all the mineral particles which will by preference adhere to them." I simply say—I don't add anything to it—but I simply say that you cannot realize that result without entraining air, and therefore air bubbles are there, which, with the kerosene or kerosene solution, is the film-forming material or effective in forming the froth.

X Q. 333. That is to say, entraining air and keeping it?

3717 A. Entraining air so as to produce froth. It may be called beating in, just as truly as the action of the cone-separator is called beating in.

X Q. 334. Then you think that in the mixing tank a froth is produced?

A. I do.

X Q. 335. Now, where is that froth separated in this apparatus?

A. If the mixing tank is used as a separate feature, it has to pass into the separator.

X Q. 336. The separating tank?

A. The separating tank. If, as Kirby says, one tank serves both purposes, than the froth is raised in the separating tank.

X Q. 337. I asked you about the mixing tank. Is the mixing tank ever used as a separating tank?

A. No, it is not.

X Q. 338. Therefore the froth is never taken out in that mixing tank, A, according to that specification; that is right, isn't it?

A. It is not calculated to be taken out there; it is calculated to be taken out in the tank where we have shown the skimming device.

X Q. 339. That is tank B; that is the separating tank?

A. That is right.

X Q. 340. And now, everything else which you have described as supplementary takes place in that tank B, doesn't it?

A. After the conclusion of the thorough agitation, whether that takes place in one tank or the other.

3718 X Q. 341. Well, it does not take place in the mixing tank, you admit that?

A. The second operation is not calculated to take place in the mixing tank.

X Q. 342. And there is no description of that in this patent—of any separating operations taking place in that mixing tank; that is true, isn't it?

A. That is true, yes; I have said that.

X Q. 343. So that whatever separation takes place in the apparatus shown in Fig. 1, takes place in the separating tank B, that is right, isn't it?

A. This is so figured.

X Q. 344. And the separating tank B would have the streams of oil flowing in—in that we have streams of oil flowing into the pulp; that is one of the things that is described?

A. I don't quite understand what you mean there.

X Q. 345. I am taking the words of the specification.

A. What do you mean when you refer to streams of oil?

X Q. 346. The language of the specification is "fine streams of the solution," page 1, lines 84 and 85.

A. That is the second step.

X Q. 347. I am talking about the separation in the separating tank B.

A. That is the separation; that is supplemental. If you will read the paragraph beginning "Second" we have this stated clearly: "In allowing the hydrocarbon coated particles to flow to the sur-
3719 face of the mass." That is his separation; "and in rendering this separation substantially complete by a second step."

X Q. 348. Rendering that separation substantially complete?

A. "By gently agitating the mass and injecting gas into the same, and preferably also discharging into the mass fine streams of the solution." That is the secondary step. It is not any part of the step which forms the froth, and the froth has already floated to the surface before that is started. That is the clear meaning of these words.

X Q. 349. That is to say, what you call the primary step and what you call the secondary step take place in the separating tank B, don't they?

A. The froth is entirely separated there in tank B; you are correct about that.

X Q. 350. Now, in this tank B we have first the material, which has been agitated in tank A, and that is the material and all of the material which flows into the tank B; that is right?

A. That is right, just as it flows off into a spitzkasten.

X Q. 351. Now, in tank B we have fine streams of the solution or oil discharged at the bottom of the tank, have we not?

A. It may be done.

X Q. 352. It is so described, is it not?

A. It says it may be done: "By injecting gas into the same, and preferably also discharging into the mass fine streams of the
3720 solution." That is one of the supplemental steps, just as the discharging of the gas is, and it may be done. It is not prescribed as a necessary feature, but I suppose he considers it an advantageous matter.

X Q. 353. In the description of the operation of this apparatus shown in the Fig. 1, this is said, is it not: "That the hydro-carbon liquid is delivered through small pipes parallel with the side hollow arms through outlet 25—25." That is the description, is it not?

A. I must connect that up first. That is correctly stated as to what takes place when the hydro-carbon liquid is used in that way, "preferably discharged in fine streams" as part of the second step.

X Q. 354. But it does not say here that you do it preferably; it says in this part of the description that you do it, isn't that right?

A. There is no question here—no qualification here; it just says that it is delivered in that way.

X Q. 355. And it is true, is it not, also that "gas is injected into the pulp in the separating vessel B." That is true, is it not?

A. That is correct. "Injecting gas into the same" is found on page 1.

X Q. 356. And that is accomplished through air jets in the rotating stirring plow, is it not?

A. We have figured in Figure 1 the same form of rotating apparatus which is operated at two different stages of the operation, and operated at different rates of speed and for different purposes.

3721 The operation in the first, or mixing tank—or if you perform that operation first in the separating tank and make one tank to function for both, that operation—that is not involved in the injecting of the air in the way that is now mentioned; that only comes in when the rotating apparatus is slowly rotated in the second step, and for the purpose of yielding small rising bubbles of air which will carry out of the gangue the mineral which was not raised in the froth in the first step. That is clearly shown.

X Q. 357. And your first step and your second step are completed in the same vessel, is that right?

A. They may be; not necessarily—oh, yes, they are both completed in the same vessel, you are right.

X Q. 358. Of course I have in mind, as you have repeatedly said that it is described in this specification as a modified instruction that you can do everything in this second vessel; that is true?

A. That is true; it says that that can be done. That is stated on page 3 of the patent, line 115. "This separate tank for performing the mixing operation is not necessary for my process, although it is preferable in some cases; as where a continuity of discharge is desired. The mixing may be done just as well in the separating tank, which can then be termed the mixing and separating tank, all in one. It is merely necessary to rotate the agitating apparatus rapidly when mixing"—and that is when I say the froth is formed—"and rotate slowly when the separation is being made." There are two different stages and two results.

3722 X Q. 359. And one separation?

A. One final separation, yes.

X Q. 360. One operation of separation?

A. No, I don't say that; there is one final separation. I have already called attention to the fact that on page 1, lines 79 and 80, we have a clear statement that the hydro-carbon coated particles float to the surface of the mass, and then we render this separation more complete—I think I am justified in saying that the separation is there indicated as well as later.

X Q. 361. But it says "in rendering this separation" does it not?

A. Well, it means the separation of the minerals, yes.

X Q. 362. Now, as a matter of fact your theory tacks on the first part of the second step to the first step, in reading those two paragraphs page 1, commencing line 68 and ending line 87; that is true, is it not?

A. That gives the first and second steps, those two paragraphs.

X Q. 363. And you tack on the first part of the second paragraph as the tail end of the first paragraph, don't you?

A. We can not connect the two except by stating what you have to start with on the second.

X Q. 364. Don't you tack those two together as the first step of the process?

A. I use these first two lines of the second paragraph as referring to the results of the first step.

3723 X Q. 365. Then they are not the first step, but only the result of the first step. Have we advanced that far?

A. Yes, they are the result of the first step.

X Q. 366. What you regard as the result of the first step?

A. Yes.

X Q. 367. In that second step we have the result of the first step, and we have the other things which you call supplemental?

A. That is right.

X Q. 368. And those things all go on together?

A. They all finish together.

X Q. 369. And the things that you call supplemental are in operation at the same time; it is a continuous operation, is it not, as described here?

A. Oh, you are—you can not talk about the first step and the second step as being in operation at the same time. There is a sequence, of course.

X Q. 370. This is a continuous operation, is it not, as described?

A. He says if you use the mixing tank and separation tank, that you can make the operation continuous; otherwise not.

X Q. 371. The specification says that this apparatus may be used continuously?

A. If you use the two tanks.

X Q. 372. Well, I am referring now to tank 1.

A. Yes, that can be made continuous; that is what the patentee says.

3724 X Q. 373. Now, we will operate it continuously. In tank A we have agitation?

A. Yes.

X Q. 374. Or mixing, and nothing else; that is all, isn't it?

A. With its results.

X Q. 375. We have in that tank——

A. That is the only operation, agitation.

X Q. 376. In tank B we have separation, have we not?

A. We have first of all a supplementary operation for the raising of additional matter, which we stir up, and the separation of that is the final separation.

X Q. 377. In tank B we have separation; that is the separating tank?

A. The ultimate separation.

X Q. 378. That separation is going on continuously, isn't it?

A. Apparently.

X Q. 379. And in that continuous operation of separation we

have the rising of the hydro-carbon coated particles to the surface and the assistance of these hydro-carbon coated particles by the streams of air and streams of oil flowing in at the bottom from the gently rotating agitator arms, isn't that right?

A. That is right, and not as a second operation continuously, but the results of the first operation are passing in, and therefore it is a reinforcing step as I consider it, so that we have the flow passing in and constituting the important operation as I have ob-
3725 served in practising this—the major portion of the operation, and then this causes the rising of the additional entrapped material, which adds to the amount of the floated material, and they together are skimmed off.

X Q. 380. So you call it a secondary operation because it assists the rising of the hydro-carbon coated particles to the surface.

A. It brings those up which are entrapped. It has nothing to do with what has been done in the first tank.

X Q. 381. It assists the flotation?

A. It assists the ultimate results, some.

X Q. 382. It does it at the same time; it is a continuous operation?

A. It can be made continuous according to the author.

X Q. 383. Well, we have taken it as detailed here, and it is continuous?

A. Yes.

X Q. 384. You call it secondary, although it takes place in the same vessel and at the same time, is that right?

A. Now, Mr. Williams, you are going back to the same vessel; I have been talking about two vessels, and so have you just now.

X Q. 385. The separation is what I am talking of.

A. (Laughing.) There is a result from the work of the first vessel which is being passed into the second vessel, which is being supplemented, I say, by work done in the second vessel, and that
3726 work done in the second vessel is what I speak of when I refer to the introduction of air and streams of liquid; that is working in connection with a slow rotation. The other operation is distinct from that operation, and takes place in a distinct vessel; it precedes it in the order of sequence, and the sum total of the two gives the ultimate froth which is taken off by the skimming bar.

X Q. 386. Although they take place in the same vessel at the same time?

A. No, I don't agree to that.

X Q. 387. They take place in the same vessel, don't they?

A. They can, but if so there would be two acts; they would be discontinuous in that case.

X Q. 388. You say they can take place in the same vessel?

A. That is what the author says.

X Q. 389. There is not a word of description of the separation taking place in any other vessel than the separating tank B?

A. I have said that the ultimate separation takes place in B, yes.

X Q. 390. And the separation which takes place in B is a separation by buoyancy, suppose we say.

A. We only get the froth after it has been first subjected to agita-

tion. There is no froth separated, but there is the potential froth of the agitated mixture, of course.

X Q. 391. And it is not separated in that vessel?

3727 A. It does not separate in that vessel.

X Q. 392. Therefore, if we are to attempt to repeat the Kirby operation we must have in one vessel a separation by the buoyancy of something, assisted by streams of air and streams of oil; that is right, isn't it?

A. If you want to carry through the Kirby operation in full detail as described in the patent you have to do as I say. If you want to prove that the Kirby first step produces a froth, you do not need to trouble yourself about the supplemental steps.

X Q. 393. You don't need to assist it?

A. You don't need to assist it.

X Q. 394. Your froth is not in need of assistance, is it?

A. It is not in need of assistance; we had it here produced excellently in the square jar.

The Witness: Mr. Williams, may I still further state my proposition about the two steps, a moment?

Mr. Williams: Yes.

A. I would like to call your attention to the paragraph beginning line 95 on page 1 of this Kirby patent. "It is thought that the use of a gas—of this gas assists in the flotation of the coated particles as set forth in the description of the second step of the process as described." I think that gives us abundant justification for stating as I say that there was a supplemental step which involved this introduction of a gas in the bottom of the separator vessel.

X Q. 395. Well, we will have to go back to this paragraph commencing on page 1, on line 68. Now, we have here four

3728 paragraphs, and each paragraph sets forth a step, does it not?

A. There are four paragraphs which set forth consecutive steps, as I see it.

X Q. 396. Now, in the first step and in fact the paragraphs are introduced by the statement that, "The process consists in the following steps"—in the first step we have agitation and whatever happened during agitation? That is right?

A. That is right.

X Q. 397. In the second step we have separation of the metal or the mineral from the gangue and whatever happens during that separation, that is the second step, isn't it?

A. Yes, but in that second paragraph there are two steps, and as I said the first and second line of that paragraph connect with the first paragraph because that expresses the result of it and then you go on to state the details of the second step.

X Q. 398. Well, now, isn't it reasonable and logical that a second step, to wit, separation, would be described as a second step even if it were the result of the first step, to-wit, agitation? That is logical, is it not?

A. Yes, but I have frequently just seen this way of statement—

have frequently seen just this very thing in connection with the step of a patent, by connecting it with that which preceded it, and that is what was done here.

X Q. 399. The second step of the Kirby process as de-
3729 scribed is separation. That is true, is it not?

A. The second step is——

X Q. 400. Separation?

A. Is the supplementary treatment for rendering separation substantially complete, it is not separation as expressed under the conditions as stated.

X Q. 401. Well, where do you put the separation which occurs from allowing the hydrocarbon coated particles to float to the surface of the mass?

A. Now, if you will analyze the last sentence of the second paragraph wherein the separation is compared, that indicates that there are parts of the separation which are to be taken together before completion. Now we have the first part of the separation stated and the result of step one. In the first and second lines they state how this separation is substantially completed or made more effective by doing something else. That is step two, and then the last sentence says when the separation is completed—something they do by agitation and they do by the injection of air—then the floating hydrocarbon concentrate is removed for subsequent treatment. Now, we are ready to take it off by the skimmer.

X Q. 402. Now, we are ready for the third step of the process?

A. The third step comes in, yes.

X Q. 403. The second step is separation?

A. In the several stages as described.

X Q. 404. In that one vessel, separation?

A. Separation is the ultimate result in the second vessel.
3730 X Q. 405. And when the apparatus is operated continuously that separation produces a float on the surface of that vessel, doesn't it?

A. The float is the final result of the separation which is here described in its several parts.

X Q. 406. Well, does Kirby describe that flotation as occurring in several steps, or does he describe it as a continuous operation, as one continuous thing? Which is it?

A. He certainly gives the several steps whether you secure them one following the other, or whether it is discontinuous because he says if you want a continuous operation you use the mixer and the separator vessel; if you don't wish to make it a continuous operation, then you can do it all in one vessel.

X Q. 407. Now, we will do it in one vessel.

A. If you will just notice the line beginning 114 on page 3: "This separate tank for performing the mixing operation is not necessary for my process, although it is preferable in some cases and where a continuous discharge is desired," and what is the antithesis of that?

X Q. 408. You read that over before?

A. I know. What is the antithesis of that?

X Q. 409. I am not answering your questions, doctor. Please answer mine.

A. I was just trying to argue.

X Q. 410. We will come to the intermittent operation. I have been trying to get you to make a picture of the continuous. Now we will come to intermittent operation. Now, in the intermittent operation what is the first step that takes place?

3731 A. The intermittent operation would take place by doing everything in one vessel.

X Q. 411. And what is the first step?

A. The first step is a rapid rotation.

X Q. 412. What is the second step?

A. The second step, following the stopping of the rapid rotation giving time for the result of it, was that you slowly agitate so as to supplement the result of the rapid agitation.

X Q. 413. Where do you find in this specification that he gives time for results?

A. I will tell you. "The mixing may be performed just as well in a separate tank"—page 3 near the bottom—which may then be termed the mixing in the separate tank. Now, it stands to reason that you can't do both at the same time. Therefore you rotate it rapidly at first and then rotate it slowly when the separation is then made. That means that the ultimate result called the separation is being made or in other words is being supplemented or completed by this slow rising of air bubbles. Then it is slow rotation and the separation is done by the skimming off.

X Q. 414. Do you find in these specifications any statement that any aeration results from that rapid agitation?

A. Not by name.

X Q. 415. And the only aeration that you find described there is an aeration which takes place during the gentle agitation by letting in streams of air at the bottom. That is right, isn't it?

3732 A. That is described as the releasing of particles by air bubbles, which you would call aeration probably, but it is not in the sense in which I used the word aeration at first.

X Q. 416. Now, the purpose of the injection of the gas is described in the specification, is it not? The purpose of the injection of air at the bottom of the separating tank is described in this specification, is it not?

A. That is described particularly at the bottom of page 412, first column.

X Q. 417. Give the page of the specification?

A. Page 2 of the patent, beginning with lines—well, I will begin in order to include the whole operation, with line 53: "Some of the hydrocarbon coated particles will float to the surface without assistance; but a considerable quantity of such particles will not be sufficiently buoyant and some of such particles and some globules of the mixture would be trapped in the sands." That is the whole object of the second step of the operation.

X Q. 418. "Globules of the mixture" means globules of oil, doesn't it?

A. Undoubtedly, but it also includes air bubbles, must do so, as a result of what we have already done. "In order to recover this less buoyant material together with the globules of the mixture, the mass which tends to settle is slowly lifted and turned over to liberate the coated particles and the globules, and at the same time a gas, preferably air, is blown into the mass, preferably near
3733 the bottom thereof." Now, then, follows his description of just what the oil bubbles do in that second step. They bring up the additional particles. But we have third steps as particularly clearly represented on page 1, beginning there at line 95, the fact that this injection of gas is a mere feature, not the main result: "It is thought that a use of a gas to assist in the flotation of the coated particles——"

X Q. 419. Then it says, does it not, "that the employment of a gas in the manner stated brings in a more powerful floating agency than anything before used, which results in the recovery of this floured oil together with numerous coated particles which would not otherwise be floated." That is a statement of the specifications, is it not?

A. That, connected with what immediately precedes it; that connected with his talk about the use of his gas step in connection with viscous oils.

X Q. 420. That is to say, the Elmore process?

A. Yes, that is the Elmore process. That does not refer to this process.

X Q. 421. Now, doesn't he say at page 2, line 54: "The injection of a gas, preferably air, into the mass which is the chief novel characteristic of the second step of the process, assists in the flotation of the hydrocarbon coated particle." He says that; he says it is the chief novel characteristic of the second step of his process, does he not?

A. What is the line?

3734 X Q. 422. Line 54, I guess that is it, 54?

A. Yes, I see it.

X Q. 423. He says that is the chief novel characteristic of the second step of the process, doesn't he?

A. Yes, of the second step of the process, and assists in the flotation.

X Q. 424. And then when he said "some of the hydrocarbon-coated particles will float to the surface without assistance" you read that as meaning some of the hydrocarbon-coated particles to which air bubbles have been attached, did you?

A. I did because they are the hydrocarbon particles which already have been taken care of by the first rapid agitation.

X Q. 425. Now, when you read a description of this float which was taken off in the second vessel, there was one part of that description that you did not read. That commences on page 3, line 55: "The floating concentrates are carried mainly at the lower surface by the hydrocarbon layer where it is in contact with the water." Now, isn't that a description of an oil buoyancy float, by its principal characteristic?

A. I have given that clause a great deal of thought and I have turned farther over to where the same form of statement appears a little fuller on the next page, on page 4 of the patent, where it says in line 20: "Most of the concentrates hang near the contact between the hydro-carbon and water, and as this contact surface becomes over-loaded with concentrates, some of them sink to the bottom of the tank." I think that describes what we have seen in
3735 looking at that square glass cell. It is always observable that there was a gradual dropping away, that dropping away takes place in the case of the air froths quite as obviously as in the case of the overloading of the Elmore solid oil layer. I don't think, from the whole description, that that is necessarily any indication that he had a meaning there of a solid mass of oil or layer of oil when he spoke about the hydrocarbon layer. "Hydrocarbon layer" there means the layer which is just above the water. Now, in my opinion, and I think I am justified in that by studying the matter—in my opinion that hydrocarbon layer there referred to is now an aerated layer from which mineral will slowly drop, and this is there referred to. I cannot connect it with the idea of an Elmore bulk oil result simply because I cannot take the Kirby process and forget the violent agitation. If you could *if you could* forget the violent agitation of the Kirby process as the first step then you could work it out very nicely.

X Q. 426. So you think that the statement that the floating concentrates are carried mainly at the lower surface of the hydrocarbon layer where it is in contact with the water describes a flotation froth carrying mineral particles on the bubbles? Is that right?

A. I think so.

X Q. 427. And then this second description that illuminated your view, that is of something that takes place in another vessel, isn't it, afterwards?

A. Well, I cannot say whether that is right or not. Yes.
3736 And I think this second description throws light on it because the same feature or the same observation, or the fact that there was a certain dropping away takes place after having spoken of the distinct breaking up by a stirring apparatus of the concentrate froth. Now, the stirring apparatus, 42, described on page 4 of the patent, line 17, the stirring apparatus 42 has its arms revolving gently within this layer so as to break up and discharge the air bubbles, and assist the separation. Then he goes on: "Most of the concentrates hang near the contact between the hydrocarbon and water, and as this contact surface becomes overloaded with concentrates, some of them sink to the bottom of the tank." That is after all the separation is completed, after the so-called skimming has been done, after the concentrates have been washed by passing over water which is moving, in motion, and after that it is desired to break up the concentrate. Now, he stirs them gently to break them up. And, as I understand, most of the concentrates hang near the contact of this froth layer.

X Q. 428. Oil and water? He don't say "froth layer," he says oil and water?

A. No, I mean out where he commenced there, in the froth layer.

X Q. 429. You don't think it is a froth still there?

A. I think the froth has not been completely broken up and I will call your attention to line 31: "The concentrates which fall to the bottom of the tank, accompanied by the hydrocarbon
3737 which adheres to them, are drawn off in a thick condition." I consider that an illustration of a frothy mixture; the concentrate is in a thick condition.

X Q. 430. Read a little further, the two streams—commencing at line 37: "The two streams, one of hydrocarbon and concentrate, the other mainly of water and concentrate, may either be filtered in separate apparatus or united and put through the same apparatus, as is found most convenient." Now, what are those two streams?

A. Well, one is the stream of hydrocarbon, distinguished from that which is here described by the expression "hydrocarbon and concentrates," and the other is the stream of water into which some of the broken down froth has gone, some mineral matter, because the breaking down of the concentrates has been described. And yet, after that description of the breaking down of the concentrates they are described as in a thick condition.

X Q. 431. As a matter of fact, in this vessel "C" there is a separation, is there not, into two streams, one of which is a stream containing a great deal of oil and the other of which is a stream containing a little oil and water? Is that right?

A. There has been by this time a breaking down and the oil and the water form these two streams, but the description in line 37 to which you called my attention, still illustrates the fact that the concentrates are present carried along in the hydrocarbon layer. There is a hydrocarbon layer now because the froth has been broken
3738 down very largely and I remember Kirby used a large amount of oil. With an amount of oil varying from 25 to 75 per cent it is undoubtedly true that when you break down the concentrated layer you would have free oil showing.

X Q. 432. And you think that that slowly rotating stirring apparatus 42 brings up the froth; is that your idea? And the froth—the metal immediately goes to the bottom?

A. It is stated there to be for the purpose of discharging the air bubbles. That means breaking up the froth.

X Q. 433. Did you ever see an Elmore float with air bubbles in it?

A. I have seen layers of oil with imperfect frothing conditions and a few bubbles of gas in it.

X Q. 434. Do you call that an imperfect frothing condition, an Elmore oil buoyancy layer with a few bubbles in it acting like pores in a cork?

A. I do not know where you draw the dividing line. I said "imperfect froth" meaning that the oil was in large excess.

X Q. 435. What is the next step from the Elmore oil buoyancy layer with a few air bubbles, is it upward or downward?

A. That is just as expressed in the experiment about which we were talking.

X Q. 436. What is the next step? Tell me. What is the condition that you get?

A. You just want me to describe it?

3739 X Q. 437. Yes.

A. That is shown in the experiment in which we took 25 per cent of kerosene oil, and first tried the Elmore effect and got quite a little flouring, quite an amount of flouring. The same mixture, without any change whatever, was violently agitated and the whole of it was changed into the aerated froth, so that we changed from one step to the other.

X Q. 438. Is there an emulsion step in between, oil emulsion step in between?

A. I wouldn't call it so. I would call it an air froth.

X Q. 439. Is there an oil froth in between?

A. I don't understand the distinction between oil froth and air froth.

X Q. 440. And you do not recognize the emulsion condition as between the froth and the solid oil?

A. Well, an emulsion of air and oil I call a froth. An emulsion in the pure sense of the word means the commingling of two different immiscible liquids, as in the case of oil and water which, in the presence of certain emulsifying agents can be so thoroughly subdivided that they will not subdivide into layers. That is what we call an emulsion proper.

X Q. 441. That is a pure emulsion?

A. We have a so-called emulsion by soap and other emulsifiers and other emulsifying agents, as I say—we have a so-called emulsion by soap and other emulsifying agents; but to call a mixture of air and oil an emulsion is not quite accurate.

3740 X Q. 442. Is it possible to have a floating emulsion?

A. Well, I don't know. I suppose there are circumstances under which you could get an emulsion floating on some other liquid.

X Q. 443. Is cream a floating emulsion?

A. Cream is a floating emulsion.

X Q. 444. What is the condition of that floating emulsion; what is it made up of?

A. It is made up of the butter fat thoroughly emulsified with the solution of the soluble components of the milk, and kept in emulsion because of the presence of certain protein material which is in the milk.

X Q. 445. What is the condition of the butter fat in the cream? You say "thoroughly emulsified," but just describe it so that the court can get a picture of it?

A. I haven't studied it strictly or under a microscope so I can't answer that question from that point of view. I would say that the butter fat was thoroughly emulsified in very finely subdivided condition through the soluble portions of the milk and if you can bring about a coagulation of the butter fat then you begin to break up the emulsion and you get the formation of a more or less clotted condition which ultimately gives us the butter separation.

X Q. 446. Now, the emulsion condition is a condition in which the oil or fat is subdivided into very fine particles commingled in a liquid in that emulsion condition?

3741 A. I don't want to pose as an authority on emulsions as some other person could, but these are some of the conditions of an emulsion in the case of a cream.

X Q. 447. And I suppose you are aware that it is possible to so treat milk that the butter fat globules will be broken up into such fine particles and the emulsion will be so fine that there will be no separation into cream. I presume you are aware of that, are you not?

A. I know that it can be held up for a period of time.

X Q. 448. That is the condition of homogenized cream, you know that?

A. Yes.

X Q. 449. Don't you know that can be held up indefinitely by dividing that up into particles of one micron?

A. I am not prepared to say. I don't know.

X Q. 450. In an air froth or an oil froth, whatever you care to call it, containing metalliferous mineral particles, are the metalliferous mineral particles carried in the lower layer in contact with the water?

A. They are distributed over the whole surface of the film which comprises the froth, but in passing there—but on standing there is very frequent separation from a froth which at first was well defined, with sharp lines, but on standing, just the dropping away that may be due to the breaking up of some of these air cells and depositing their load.

3742 X Q. 451. That is in fact due to the breaking of bubbles, isn't it?

A. That disintegration in some cases—I don't know that I have studied the problem of that disintegration to see just what are the conditions most favorable for it—but I have observed it frequently.

X Q. 452. But in a true mineral froth, so long as it maintains its stability, the metalliferous mineral particles are distributed all through the froth in the surface of the bubbles? That is right?

A. On the surface of the air cells, yes, sir.

X Q. 453. Now, it is a fact, is it not, that the Kirby specification enlarges upon the use of a thin hydrocarbon liquid in place of the thick viscid oils used by other inventors, as one of the most important features of his invention. I refer to page 4, commencing with line 52 of his specification.

A. He says, in line 52, that the advantage of the thin hydrocarbon oil in place of the thick viscid oil used by other inventors is for one particular reason. He states that the use of the thin oil makes filtration comparatively easy and permits cheaper methods than the centrifugal machine and the filter process. He contemplates a large amount of oil, from 25 to 75 per cent., and he did not desire to have all of that oil burned up with the concentrate in the end. He desired, and in that way he contemplated a recovery of the oil ultimately, and filtration is the method he refers to, and with a thin oil it is obvious that filtration is more easily practised than with

viscid oil, and does away with the necessity of using centrifu-
3743 gals. That is the feature described in the California Journal —Technology as part of the Elmore improved process.

X Q. 454. And he also speaks of the advantage of being able to separate practically all the oil by distillation?

A. In case of the addition of distillable oil, that is the theory.

X Q. 455. That is the fourth step of his process, referred to on page 1?

A. Yes.

X Q. 456. The third step being filtration?

A. Yes.

X Q. 457. The fourth step is distillation?

A. Yes.

X Q. 458. Have you ever seen the Kirby process in operation as described in the specification, with the employment of everything that is described in the first step and the second step, as there described on page 1 of the specification?

A. I have never seen the carrying out of the second step by skimming off with the skimming bar; I have never seen that practised. I have only practised and witnessed the operation of the Kirby process insofar as it was desirable to settle the question as to what was the result of the Kirby process carried through the first step to see what the result of that was. The supplemental step I never practised.

X Q. 459. I asked you if you had ever seen carried out everything that is described in the first and second paragraphs, the first and second steps.

3744 A. Not in the second paragraph, no, I have not.

X Q. 460. Did you see that done at the Miami trial in your presence by the plaintiff?

A. I did not see the Kirby process illustrated in that way at all.

X Q. 461. Did you see the Kirby apparatus operated?

A. I don't recall that I saw that process of skimming.

X Q. 462. Well, if your recollection was complete, you would remember that there was a slowly rotating skimming bar at the top, which pushed the flowing layer of hydro-carbon, floating particles with a few air bubbles in it, and that they were collected. Don't you remember that now?

A. I don't recall the experiment, no.

X Q. 463. And it was repeated in the Circuit Court of Appeals in Philadelphia, wasn't it, and you were there?

A. I didn't see it.

X Q. 464. You said today that the Wolfe patent, which appears in complainant's record in the Hyde case, Vol. 3 page 966, discloses an operation which necessarily produces a froth, is that right?

A. I said that the operation of what Wolfe describes as the rotating turbine, which is otherwise described as the Johnson mixer would necessarily produce a froth if rotated with a flowing ore pulp and the oil under the conditions that are shown.

X Q. 465. That is to say that the sulpho-chlorinated oil

3745 used as it is described in that patent, would overflow as a froth; is that your understanding of the disclosure of that patent?

A. That disclosure of that patent is that the sulpho-chlorinated oil, as stated in line 68 and following of page one—the sulpho-chlorinated oil adhering to the mineral of the ore, floats. Now, that follows after we have had the rapid rotation of what he calls the turbine wheel in the mixture of ore and pulp. I have never experimented myself with the sulpho-chlorinated oil, therefore I am only judging by my belief of what it is for, and what purpose it would accomplish. I am also strengthened in that belief by the testimony of Mr. Sulman that he thought they were efficient baffles, and that the Johnson mixer was capable of acting as a substitute in the same way as the Gabbett cone mixer, and then about the description here in the patent of the circulation, set up in the vessel, I believe that we have there a vortex motion which would of course develop aeration as the result of the rapid rotation.

X Q. 466. But I asked what would happen in this process.

A. I don't know what sulpho-chlorinated oil is,—a good oil, or what type of oil it is from any personal knowledge.

X Q. 467. You don't know what happens in that process?

A. Not from personal knowledge.

X Q. 468. Now referring to the testimony of Dr. Lieb-
3746 mann in the Hyde suit at page 557 volume 2 of complainant's record.

A. I have that.

X Q. 469. You quoted that, as I understand it, as a description of a normal Froment operation. You certainly applied it to what you regarded as a normal Froment operation, did you not?

A. It is a description of a test tube experiment carried out by Dr. Liebmann, and what his proportions were does not appear clearly. He said, "the amount of carbonic acid which could have been evolved was so small that it would have been dissolved in the water which was present." That was my quotation. I quoted that to call attention to the fact that Dr. Liebmann, as well as myself, recognized what a moderate amount of carbonic acid would be absorbed, and unless there was a very large evolution of carbonic acid and very expeditiously, that we had to consider only the gas which was not dissolved, the excess, in determining how much it would contribute to the air mixture which would form the bubbles.

X Q. 470. Do you know whether or not that was a description of a normal Froment operation?

A. I think that he presents that as an illustration of what Dr. Byrnes had done in connection with the Froment patent, and he claims that there was an insufficiency of oil in answer to cross question 59.

X Q. 471. He also said, did he not, that there was a total insufficiency of sulphuric acid—for the purpose of assisting your determination of this matter, if you will turn to page 555, you will

3747 see that this commences with the reference to a certain paragraph in question 34. Do you see that?

A. Yes.

X Q. 472. Now, if you will turn to page 475 you will see that the paragraph which is following the last paragraph on page 475—You will see that that is the same paragraph; "I took 10 grams of defendant's ore which had been crushed to an 80 mesh, mixed with 30 cc. of water, and added thereto .036 grams of sulphuric acid (which I had to dilute in order to be able to convey it into the test tube) and 1 drop of cottonseed oil." That is the description of the experiment.

A. Yes, but does that description give you the amount of calcite?

X Q. 473. If you will follow it up——

A. Because the sulphuric acid and the calcite are the two things that react.

X Q. 474. If you will turn to defendant's record page 165 you will see on the preceding pages the reference to Dr. Byrnes' experiment, and you will find that Dr. Byrnes was carrying on Froment, not only with insufficient sulphuric acid, but without putting in any calcite.

A. Oh, I see. Well, I can not understand that that experiment was normal, if the calcite was omitted, because the whole feature of my illustration of Froment was to follow Froment's example as given in his Italian patent, in which there was 1 gram of calcite for every 10 grams of ore, and 2 drops of sulphuric acid. Now, I cal-

3748 culated that that 2 drops of sulphuric acid could not decompose more than a fraction—more than one-quarter at the outside, of the calcite, and under those circumstances the total amount of carbonic acid gas which could be gotten, without reference to this dissolved in the water, as not more than half of the contents of the tube, and I called attention to Dr. Liebmann's statement there as to the solubility of the carbon dioxide in the water when a moderate amount was produced, as backing up and substantiating my view that the carbonic acid would not play a very large part, and under the increased pressure which for a moment exists when the tube is closed and shaken, you have much more than one atmosphere, and I do not believe that that amount of carbonic acid would do more than start the reaction. In the experiment which I carried out, with very violent agitation for a few moments, there was not a great deal of excess pressure developed at the cork.

X Q. 474*a*. Now, these operations to which you refer, when you referred to that testimony of Dr. Liebmann, are representations in the test tube proportions of these experiments described by Dr. Byrnes alleged to repeat the Froment British patent?

A. Yes.

X Q. 475. And in those experiments he took Black Rock ore; he did not put any calcite, and he used one cubic centimeter of sulphuric acid to 492 grams of ore, and 1700 cc. of water. Now that was not a Froment operation at all, was it?

3749 A. Well, I could not say that it was; I would have to calculate it out.

X Q. 476. And you will agree that Dr. Liebmann thought that any carbon dioxide that would be produced under those circumstances would be dissolved in the water and therefore useless in the process, would you not?

A. The 1 cc. of sulphuric acid would have to act upon the manganese carbonate in the Black Rock ore, and apparently it was not acting enough. I would not, myself, at all, illustrate a—illustrate the Froment experiment that way.

X Q. 477. Now, referring to the British Froment specification and these words which I think are the same in the British patent as in the Italian—Froment says in the British specification, page 2, commencing line 39: "If the limestone is in excess or readily attackable, the rapidity of the separation is so great that the proper pulp is forcibly projected outside the vessel." Now, you took a proportion of sulphuric acid which could not, by any possibility, have decomposed the limestone that you used, isn't that right?

A. That is correct; it could not have decomposed all of the limestone.

X Q. 478. Froment gives a certain definite proportion of limestone, doesn't he?

A. He tells you one gram to every ten grams of ore, in the patent, and a few drops of sulphuric acid.

X Q. 479. So he gives you a definite proportion of limestone, and as you read it, not enough sulphuric acid to decompose your
3750 limestone, and then he tells you that if the limestone is in excess you will get into trouble; isn't that what he says in his specification?

A. That is what he says here, yes; only I didn't get it.

X Q. 480. When you made your determination with olive oil layers, what were the conditions as to the condition of the water and as to the times that you waited when you got your 9% for the thin layer of olive oil?

A. I took a test tube such as was shown here, of an internal diameter of one inch, and I made the first trial with water at 25° centigrade, which is room temperature, and I dropped the olive oil, without previous warming, at the present temperature also of the room, from a pipette, which was graduated in tenths of a cc., so I could measure fractions. At .32 of a cc., or a little over three-tenths, I looked at it from the side, as the test tube was held up, and that gave me very distinctly—more than a thin layer—what I would call a thick layer; but I looked at it from above, and I found that there was not a layer sufficient to cover the water. Therefore I passed on with the trial, and added additional olive oil until I reached .77, or rather more than two-thirds of a cc., and the layer, which was quite perceptibly thick at the side, was still not in complete contact. I did not jockey it at all by shaking it to spread it out in contact, but I tested the matter fairly.

3751 X Q. 481. You gave it a good deal of time, didn't you?

A. I went ahead as quickly as I could put it in, and I went on and added further oil, and at one cc. of this olive oil, dropped in in the same way from above, and looked at, I had a complete covering

for the water in this tube; in other words, the layer of oil completely touched the glass all around. Looked at from the side this was more than a thin layer; it was really a thick layer. One cc. of the oil figures out 8.2% of oil reckoned on 10 grams of ore.

X Q. 482. And that was the thinnest possible layer that you could get for a covering of the whole surface of the water, wasn't it?

A. At that temperature and in that experiment.

X Q. 483. Now, you said in your testimony this morning that you had seen a machine made according to the Froment description operated so as to produce a froth. That is right, is it not?

A. In the Froment machine, that is right.

X Q. 484. That is a machine made according to the Froment description?

A. Yes.

X Q. 485. Where was that?

A. That was an experiment that was made in the trial at Wilmington, with the Froment machine, and is described in the exhibit book of that trial on page 888 of that exhibit book, volume 4 of the Miami case.

X Q. 486. Do you remember what the recovery was of that operation?

3752 A. The total zinc extraction by weight was 72.39.

X Q. 487. That was what you called the power driven Froment machine, wasn't it?

A. It is so called; it was the larger machine. There was a small Froment machine.

X Q. 488. You had a hand machine there that was just like the Froment experimental apparatus, didn't you?

A. I believe there was also that there in court.

X Q. 489. And that was operated and it produced a froth, didn't it?

A. I haven't found a record of that. A large number of results were given in what is called the report book, but what I have taken is just those that were accepted in court as shown in the so-called assay book. I have seen the small Froment machine operated independent of that trial and assisted at the operation.

X Q. 490. In the operation of that hand machine which was a reproduction of the Froment experimental apparatus, don't you remember that the first recovery was 2% and the second recovery was 6%?

A. I don't remember anything about it. I have not found the record of the results of the small machine.

X Q. 491. Turn to exhibit record page 235, and there you will find the assays of those tests and the last one is the first Froment; and there you will find that the recovery as determined by the plaintiff's assayer was 1.95, and the recovery as determined by the defendant's assayer was 2.06?

3753 A. I would like to see that; I don't follow it.

X Q. 492. Here is the page; volume 4. That is right, is it not?

A. I see the figures which you have quoted, but I don't find that; I don't think it is in my book.

X Q. 493. This is the transcript——
A. I have found it.

Mr. Scott: Why don't you ask the witness a question so we can all hear it?

Mr. Williams: The witness was trying to find a reference in the book and I am trying to help him. Have you any objection to that?

Mr. Scott: Well, let the witness find it.

X Q. 494. Have you found in this book the figures to which I called your attention?

A. I have found the figures; I don't know to what they refer, because I can not sufficiently identify this experiment with anything which I ever saw. These figures appear in a summary of the assay of those tests. When those tests were made or where they were made or whether I was present, I don't know.

X Q. 495. Now, if you will take the report book, you have it in your volume?

A. Yes.

X Q. 496. And turn to page 38.

A. Report book, series C of Froment; here is the small Froment.

X Q. 497. Now, that is the description of that experiment?

A. With the large Froment machine, yes.

3754 X Q. 498. Aren't you able to identify what I have shown you as the assay of the result of that experiment; that was the first Froment experiment so described. And then, to refresh your memory still further, I will ask you to turn to Page 236, the next page after the one we had, and take the bottom experiment there, the second Froment series C, No. 6, and the other was series C, No. 6, and there the recovery according to our assay was 4.83, and according to the defendant's assay was 5.29. Don't you now recognize those as the results of that operation?

A. I did not see that operation that I know of. As I understand it, the experiments which were picked out from the assay book and shown to the court are those which were recorded later—picked out from the report book and shown were those enumerated later under the name of assay book, and I did not see all those experiments, and I am not able to say whether I saw either of these experiments with the Froment machine about which we have here the assay results.

X Q. 499. Now, turn to the assay book page 889 and——

A. Well, I see that, and I see the last paragraph of that page also. We have here a report of two experiments, and the statement is made at the end: "These tests are for observation only in the production of mineral froth, and the apparatus was not designed or adapted for quantitative work, hence the recovery figures signify nothing."

X Q. 500. How are those recoveries figured there. That is just an argument, and I want the facts.

3755 A. I don't know what they represent.

X Q. 501. "The extraction, based on the weights and assays

of the concentrates and tailings was 5.66%." That is the second experiment. That was on page 889?

A. That is what is stated.

X Q. 502. And as to the first experiment, therefore, have you any statement as to what the extraction was. My statement was correct wasn't it?

A. Yes, and the explanation is given below.

X Q. 503. Now, those experiments that are reported in that book were made in your presence, were they not?

A. If these were repeated in court, then I saw them.

X Q. 504. And they would not be here in this assay book if they were not repeated in court, would they?

A. I guess that is right and proper.

X Q. 505. Now, when you testified in the Miami case you had a theory in explanation of flotation did you not?

A. I had at that time stated that the simple selective action of the oil for the mineral as against gangue, and the adhesion of the oil to the mineral and the wetting of the gangue with water was not a broad enough statement, and therefore I discussed somewhat, as far as I knew it, the effect of surface tension. I was very much at a disadvantage in discussing that, for the reason that I am not a physical chemist, and I have never made any experimental
3756 studies or observation of surface tension phenomena, and therefore I only gave my view of the theory as representing the best information that I could obtain on the matter, and I recall that Dr. Liebmann coincided with my views in his similar expression, that it was the broader view of the phenomena, that is, that surface tension was an important feature in determining the question of froth formation. Further than that I did not go. I was in the dark as to the complete theory in the matter, and I remained in the dark until I heard the matter discussed within very recent time.

X Q. 506. As you then explained the theory of flotation you regarded a reduction of surface tension as essential to flotation, did you not?

A. As essential to the concentration in the film and the development of increased viscosity in the film, which I stated I understood was a result of this lowering of the surface tension.

X Q. 507. And I believe you very modestly said that you did not regard that as a complete explanation?

A. I certainly said so.

X Q. 508. You are familiar, are you not, with patent No. 962,678, to which you referred in your direct examination and which was put in evidence, that being known as the solution patent.

A. That was the second patent in suit in the previous trial?

X Q. 509. Yes.

3757 A. Yes, I familiarized myself with this patent.

X Q. 510. In fact you made a careful study of it and testified about it in the Miami suit; that is true, is it not?

A. I testified about it at that time.

X Q. 511. And gave it careful study?

A. I did.

X Q. 512. This patent discloses, does it not, a process of concentrating ores which consists in mixing the powdered ore with water containing in solution a small quantity of a mineral frothing agent; agitating the mixture to form a froth, and separating the froth?

A. That is stated in the claim to be the process.

X Q. 513. That is disclosed in this patent, is it not?

A. Well, when you ask my opinion about that I can not answer that categorically, because I would have to refer to the fact that mixtures containing soluble portions which are in themselves frothing agents, are described, as already testified to; and when I analyzed this patent at Wilmington I referred to the prior reference to such soluble frothing agents in the Cattermole patent, cresol and phenol for instance.

X Q. 514. I limited the question to what this long document disclosed, and I read the language to summarize it. That is my question; not whether it is the first disclosure or whether it is a proper claim, but whether or not what I read to you is disclosed in that patent.

Mr. Scott: I object to that question your honor. It apparently has no relevancy in this case. It is absolutely incompetent
3758 as to what some patent means that we have neither set up in anticipation and which in fact is here and which is not involved in this suit.

The Court: Didn't you introduce this in his testimony in chief?

Mr. Scott: Some slight reference was made to it for some purpose that I have forgotten.

The Court: At any rate, this man is an expert. It may even go to test his knowledge. I hope there will not be too much of it. The objection will be overruled.

A. I think this is disclosed as I stated it.

Mr. Williams: If your honor please, I have a few notes which I can not put my hands on at the moment because the witness finished earlier than I thought he would and I will finish up the cross-examination very early in the morning.

Whereupon an adjournment was taken until tomorrow morning, Friday, May 4th, 1917, at 10 o'clock a. m.

Friday, May 4th, 1917—10 a. m.

Mr. Kremer: If your honor please, the order in connection with the filing of the amended and supplemental bill gave us—I think the order reads until Saturday in which to file the answer. I have the answer dictated, and it is practically completed; I think I will be able to file it today; however, I wanted to inquire as to
3759 whether or not the order included Saturday. I have engrossed or embodied the answer to all of the amendments to the complaint, so that there will be just one pleading in that respect

and one pleading to the supplemental answer, so it really necessitated two pleadings.

The Court: Proceed with the examination.

Dr. SADTLER.

Cross-examination resumed.

By Mr. Williams:

X Q. 515. When was your attention first called to the California Journal of Technology; I mean, of course, the article therein which was introduced in evidence.

A. I think it was probably about the end of 1914, some months before the Miami trial.

X Q. 516. Just before the Miami trial?

A. Not just before, but some months before.

X Q. 517. You remember, of course, that it was called to the attention of the plaintiff just before the beginning of that trial, when we had all gathered at Wilmington and were ready to start with it; that was the first knowledge you had of it, at the time of the trial?

A. Well, that was not quite the first, because I had been told of it some little time before, and I went to the library in Philadelphia, of the Franklin Institute, and looked up the original Journal which was there on file, and I had photostat copies made of it some little time before the trial.

3760 X Q. 518. Now, comparing the Kirby process as you understand it with the Froment process as you understand it, they are essentially the same in their froth formations, are they not?

A. They involved in both cases the formation of an agitation froth by analogous devices. The conditions are considerably different in some respects. The Froment process, as carried out on the larger scale and as described in the Froment description, uses relatively small quantities of oil, as stated in the Froment description, 1% of oil for ore containing 5% of metal, 1½% of oil for ore containing 10% of metal and 2% of oil for ore containing 15% of metal. On the other hand, in the Kirby process we have a different kind of frothing agent, namely the light kerosene, or a solution of bitumen in kerosene, and it is used in a relatively much larger amount; but I find no difference in the result, looked at as a principle. In either case there is a complete froth formation, which froth becomes mineral-laden, whether the amount is 25 to 75% of Kirby or whether it is the smaller amount of Froment, and that takes place in the Froment procedure also in a so-called mixing device in which there is a centrifugal mixing device and from there it passes to the so-called coil-vat; in that respect there is a close analogy.

X Q. 519. Now, comparing the Froment patent, British and Italian?

3761 A. The Froment patent is a simple description of a principle illustrated by an example, and we have there nothing more than an illustration of the independent formation of

an air froth by agitation, aided in this case by the presence of the carbon dioxide which is evolved in whatever degree it may be, due to the reaction of the sulphuric acid and the calcite. But the Froment example and the phenomena observed by Froment, and made the basis of his patent, are simply illustrations of the principles and the broad results which follow. We have to turn to the Froment description, of course, for working apparatus, if that is desired.

X Q. 520. According to the Froment principles, as you understand them, the froth is composed of air bubbles with a coating of sulphide or metalliferous mineral. That is right?

A. Mineral and mixed gases.

X Q. 521. And according to the Kirby process as you understand the froth is composed of air bubbles with a coating of metalliferous minerals?

A. I think so. I so conceive it.

X Q. 522. Well, that is true.

A. I do so conceive it to be true, yes. That is what I meant to have said.

X Q. 523. Now, will you turn to the file, wrapper and contents of the Kirby patent, Hyde record, defendant's record page 517 and at the top of page 517 you note that the claim 2 was rejected by the patent office on Elmore, Sulman and the British patent 12,778 to Lake?

3762 A. Claim 3 you speak of?

X Q. 524. Claim 2? That is true, is it not?

A. The claim 2 which was rejected, does not speak——

X Q. 525. Just answer the question, please?

A. Claim 2 was rejected by the patent office in view of those patents named by you.

X Q. 526. And one of these is the Froment British patent?

A. That is true.

X Q. 527. Now, claim 2 which was rejected appears at page 510 and is as follows: "The process of separating minerals, which consists in mixing together pulverized mineral material, a considerable quantity of water and a substance immiscible in water but of less specific gravity, and which, in the presence of water, will adhere to some of the mineral particles and not to others; in gently agitating the mass and blowing into the same a gas to assist the flotation of said immiscible substance and the mineral particles which have become coated therewith; in removing the floating layer and separating said adhering substances from said mineral particles, substantially as specified." That is right, is it not?

A. That is a correct reading, yes, sir.

X Q. 528. Now, we will turn to page 526, and there we find, do we not, the arguments that were submitted on behalf of the applicant as to the rejection of that claim 2 on the Fromeent and other patents? That is right?

3763 A. There is an argument here and I am just beginning to read the portion——

X Q. 529. Now, I will read a part in that argument, commencing

about the middle of page 520. "Lake's process"—that is the Froment British patent, is it not?

A. That refers to the British patent agent, I have no doubt.

X Q. 530. And in whose name the Froment patent was issued?

A. Yes, sir.

X Q. 531. "Lake's process is for a specifically different thing, and does not tell the public anything about the advantage of gently agitating a mixture of water and mineral particles coated with an immiscible liquid and assisting their separation by blowing in air." Now, I will say here that there are some typographical errors in the print which will appear upon a comparison with the original file wrapper and contents and I am reading it with the corrections. "Lake discovered that gas bubbles liberated in mineral which he describes become coated with chalcopyrite dust. This discovery is absolutely without value in the applicant's process since the mineral particles are already coated with bitumen, and the problem presented is one of separating the bitumen from the water." Do you agree with the statement made on behalf of Kirby in the prosecution of his application for a patent, that the discovery that gas bubbles
3764 become coated with a dust of metalliferous mineral is absolutely without value in the Kirby process?

A. No, I do not agree with that. I agree with the first part of what you read that the Lake process is for a different process from gently agitating. I agree with that, and I do not agree with the idea that gas bubbles in the Kirby process may be coated with chalcopyrite dust, as it is termed, simply because we have the several elements in the separated froth. We have the coating that he speaks of with bitumen, but that bitumen is a solution in the thin kerosene and constitutes the oil film. Now the oil film concentrates in itself the chalcopyrite dust or the other mineral particles and we can have the coating which is referred to here by the attorney for Kirby, and we can also have the separating in that film of the mineral particles, and do have it.

X Q. 532. You do not agree there with the statement?

A. I do not agree with the statement as it is given here without qualification.

X Q. 533. And you believe that bubbles containing some gas coated with metalliferous particles are clearly disclosed in the Kirby patent? That is what you believe?

A. That bubbles coated with oil films of the character of the oil used by Kirby, that take up the load of metalliferous mineral, and that forms the strong coating of the bubble and enables it to give us the concentration.

3765 X Q. 534. Doctor, turn to page 510. I will read to you claim 1 of Kirby.

"The process of separating minerals, which consists in the mixing together (*a*) pulverized mineral material (*b*) a considerable quantity of water (*c*) a substance immiscible in water, but of less specific gravity, but which, in the presence of water will adhere to some of the mineral particles and not to others; in removing from the surface of the mass the floating immiscible substance and the mineral particles

to which it has adhered; in the filtering the material so removed, and in distilling the filtrate to drive off and recover such immiscible substance, substantially as specified." Do you agree with that statement of Kirby's invention as he originally filed it in the Patent Office?

A. That is a distinctly different statement, less complete than now appears in the first claim of Kirby's patent as issued. At the same time I call your attention to the fact that what is here stated allows our understanding of a froth formation and float, for the reason that we have in here these words, "in removing from the surface of the mass the floating immiscible substance and the mineral particles to which it has adhered." Now, it was quite conceded in the course of the discussion of the Elmore patent that the Elmore separation of the mineral particles did not take place in the surface of the Elmore oil layer. Here we have the separation of the floating immiscible
3766 substance and the mineral particles from the surface of the mass, which means a froth; but it was more elaborated and more clearly stated in the final form in which the Kirby patent was issued.

X Q. 535. Isn't it an essential feature of every process wherein they float the metalliferous particles to the surface that they separate that float in order to get the mineral particles away from the gangue which is in the pulp?

A. Of course you separate the mineral particles that have been taken into the oil, but there are two conditions existing; the one case in which the float in the form of a froth is on the surface of the oil, and the other case as in the Elmore process, where it is carried by buoyancy throughout the oil layer, and the separation takes place, not from the surface, but takes place by means which have been described in the California Journal of Technology, by centrifugal or other means of that type, in which they get a perfect separation of the whole mass of the oil layer with the mineral.

X Q. 536. I will read the question. (Last question read.)

A. I can answer yes, to that.

X Q. 537. And isn't it a very good description of that operation, if we say "removing from the surface of the mass the floating immiscible substance and the mineral particles to which it has adhered"?

A. It is a good description if we apply it to the removal of
3767 the froth. It is not a good description if we apply it to the separation involved in the Elmore process.

X Q. 538. The Elmore process, does not the floating layer of oil carrying mineral particles overflow so that by that overflow it is removed from the surface of the mass of the pulp; answer directly, please.

A. They are carried undoubtedly in the oil layer, but not on the surface.

X Q. 539. Isn't the oil layer carried on the surface of the pulp until it is overflowed or removed from the surface of the pulp?

A. Yes, it is.

X Q. 540. Now, in the Froment description at page 733, of complainant's record, Volume 3, in the Hyde case——

A. I have the whole translation of Froment here, although I do not follow your paging.

Mr. Scott: I will give it to you Doctor. Here is page 733.

X Q. 541. Under the heading "Instructions," is it not stated that "in order to arrive at a perfect disintegration of the constituent particles of the ore, without rendering it impalpable, it is necessary to do the crushing in two operations," and is it not further stated that "on leaving the second crushing mill, the ore will further be submitted to two or three spitzkastens for eliminating the slimes, which is too fine to be treated, and which could not be treated
3768 by any hitherto known method." That is the statement of Froment's description, is it not?

A. That is the statement.

X Q. 542. And that is an instruction, is it not, to deslime the material that is treated?

A. That is what it practically amounts to.

X Q. 543. And in all these experiments which you have referred to or which were conducted at the Miami trial, it is true, that the ore was not deslimed, and you so admitted, did you not?

A. I don't recall the condition of the ore when we used the Froment apparatus, large or small machine. There is no such limitation, of course, in the Froment patents, Italian or British.

X Q. 544. I did not ask you that; please confine yourself to the question.

A. I don't recall in regard to the separation of the ore for the Froment machine, because I had nothing to do with the preparation of the ore.

X Q. 545. You don't remember that you admitted that that ore was not deslimed?

A. I don't remember that I admitted it, because I had nothing to do with the preparation of it. If I did admit it, it was because I was told so by hearsay.

X Q. 546. Is there in the Froment patents Italian or British, any mention of the use of heat or of heating the pulp; answer directly, please.

A. I believe not.

X Q. 547. You know there is not?

3769 A. I don't remember—Yes, I know there is not any mention of the matter of temperature.

X Q. 548. Now, we will turn to the record in the Miami case, Volume 2, page 1004. To make the matter as short as possible, it appears on the preceding page and on this page, does it not, that you summed up the question of the bearing of surface tension on ore concentration and stated three cases were to be considered; first, the normal surface tension of the water; second, where the surface tension of the water was raised, and third, where the surface tension of the water was lowered. That is true, is it not?

A. That is the classification under the head of the bearing of sur-

face tension on ore concentration; there were three cases, as you stated.

X Q. 549. Now, I will read to you what you said about the third case, from page 1004: "Now, third. In the third case the surface tension of the water may be lowered by dissolving certain organic compounds or contaminating or so called modifying agents. This third class includes all agitation and aeration processes which are dependent upon frothing or bubble formation, whereby the buoyancy of the air becomes effective for raising minerals. And as I have already indicated in the matter which I read, this would include the effect of emulsified oil in lowering the surface tension either by soluble or insoluble contaminating agents—lowering the surface tension and thereby facilitating froth rising." I have read your evidence correctly, have I not?

3770 A. Yes, sir.

X Q. 550. Now we will turn to page 1162, and I will start with X Q. 1238. "Q. What is your idea of what an oil froth is—I don't quite understand it. A. The word is used a little indiscriminately. Sometimes the oil emulsion is called oil froth, because sometimes an emulsified effect is sometimes referred to as froth, but as the word froth is more particularly used in reference to these processes, I must differentiate between oil emulsion and oil formed froth, which I am trying to do. X Q. 1239. What is oil emulsion? A. It is an emulsified mixture of oil and some aqueous liquid, in which the air plays a very secondary effect. X Q. 1240. What are the bubbles made of—They are air? A. Probably air." I have correctly read your testimony, have I not?

A. You have.

X Q. 551. We will turn to page 1170: "X Q. 1304. Do you put forward, as an explanation of the phenomenon of a mineral froth produced by agitation or produced, as you have said, the doctrine of surface tension as a complete explanation of the phenomenon? A. It explains the case of soluble agents, as probably the only scientific explanation, because we can not assume there that those dilute solutions of the frothing agent have the selective coating action which is ascribed to oil. It can only be made to cover the case of oil used in small quantities, because by the use of oil in small quantities, we have present the emulsification of the oil, and oil emulsion
3771 there acts distinctly in the way of lowering surface tension, as started by these authorities which I have quoted. So that it is broad enough to cover both oil used in small amount and the use of soluble frothing agents, and it makes it unnecessary to dwell particularly upon the selective action of oil, which of course exists for mineral particles." Have I correctly read your testimony?

A. You have correctly read what I said at that time.

X Q. 552. We will turn to page 1181, commencing with R. Q. 1365. "Q. Upon your previous examination you discussed the theories underlying the formation of froth, and referred to the early theory of the selective affinity of oil, and then went on to say: 'I am inclined to believe that at the present time the general view is that with the flotation processes which use small quantities of oil there is a broader

explanation.' I want to ask you whether that broader explanation is confined to the use of small quantities of oil, or includes all cases in which a froth is formed; that is, by a small quantity of oil, referring to that term in the sense in which it is used in Patent 835,120. A. I had in mind there the thought that particularly when small quantities of oil would be used, that the oil would be easily emulsified, and we would then have that condition of oil emulsion which it is stated has the same influence in the way of lowering surface tension that the soluble frothing agent has, or soluble contaminating agent. But if the oil be in somewhat larger amount, it is only a question
3772 of its emulsification. A portion of it is always emulsified with the energetic agitation which is carried out in these processes for air froth raising. The presence of a trifling amount of unemulsified oil would not interfere, as I could see, with that way of operating, and I think that, until the oil amounts to a considerable amount, that it will be emulsified sooner or later in the continuance of that first stage of operation; that is, the agitation; and there will be enough of it emulsified very promptly to make it possible to include it in this explanation, or this underlying theory that I spoke of." Have I correctly read your testimony?

A. You have correctly read what I said.

X Q. 553. Now, we will turn to page 1331, commencing with Q. 34*a*. "Now, Doctor, I think if you will take the rest of the session and describe the operations which were performed and the results, it will assist in understanding this matter. A. In this last experiment, the oil taken was chosen so as to typify the thick viscous oil of the Elmore process, but taken in the amount of 25% which is utterly inadequate to effect the desired flotation by the buoyancy effect alone, which has been stated by witnesses repeatedly, requires the use of 100 volumes, or 100% to realize the bulk oil flotation. Nevertheless, this was given careful and slow rotation, which would correspond to the Elmore mixing treatment, and we then examined the oil layer, and it was found to be broken, and the oil globules had dropped out because of the overloading with mineral, and quite an amount
3773 of these oil globules gathered below. The mixture, after a short time for observation, was then shaken vigorously for a few minutes, and we then had an air froth formed, although the air froth did not illustrate a very perfect separation, because of the character of the oil and the large amount. Q. 34*b*. The residuum oil—Is that suitable for the formation of an air froth, a mineralized air froth? A. No, sir, it is not." Have I correctly read your testimony?

A. You have.

X Q. 554. We will turn now to page 2085, which is in volume 3 and I will commence with the answer to question 29, with the general statement that the—well, I will commence with the question so as to make it clear: "In scenes 20 to 44, a series of pictures was projected, showing the current of air bubbles, passing through a water, clear, and water modified with different reagents—different substances.

What comments do you have to make upon the experiments shown in those pictures?

"A. These were very interesting illustrations, and, essentially, they illustrated very well what already had been shown in the circular aeration cell which I have shown in my testimony. We found the same thing practically by modifying water, first starting with pure water and seeing the formation of air bubbles in pure water, and then adding a single drop of cresol, and seeing the effect of that, producing the breaking up of the larger bubbles into fine air bubbles,
3774 a condition that forms, momentarily, the whitish layer of finely divided air bubbles due to the modifying effect of the cresol.

The pictures of Dr. Grosvenor show the matter very clearly and beautifully, and better perhaps than the single operation, because it was possible to follow the condition and compare more graphically, I should say, this condition than by watching the single experiment. I have to say, generally, I agree entirely with the statement:

'Agitation of water unmodified by a mineral frothing agent produces air bubbles which coalesce, rise and burst. Mineral frothing agents produce small and persistent air bubbles.'

"I believe that is well shown." Have I correctly read your testimony?

A. You have. I would like to say that the text is hardly accurate there. Referring to the pictures of Dr. Grosvenor, the expression is: "Due to the modification of the cresol." It should be due to the modifying effects of the cresol, but you have given it correctly as it appears here.

X Q. 555. Now, page 2092, commencing in the second paragraph of the answer to question 45; "Now we had two experiments, of which the second one only need be carried out, using light pine oil which is insoluble oil, and will be taken in the amount of three per cent, reckoned on the water taken. With that we had meant to compare the effect of .1 per cent. What will be produced here will be an oil emulsion, or rather, an emulsified oil, I would prefer to call it,
3775 which is a froth raising agent." Then, passing down to question 46, thereby omitting the statements of counsel: "Are you going to do the experiment first with the small or with the large quantity of oil? A. First with the small quantity. We have here the effect of a modifying agent, although not a soluble modifying agent. Emulsified pine oil has the same effect of lowering the surface tension, which is the end to be achieved by the soluble frothing agent, and the froth produced may be a little more lasting. (The experiment referred to was performed). This is with an insoluble agent." Have I correctly read your testimony?

A. That is correctly read, and it is what I said then. I thought so then.

X Q. 556. Continuing on page 2093, question 49: "In connection with scenes 46 and 47, Doctor Sadtler, I notice that Dr. Grosvenor prefaces his remarks by the statement: 'Practical results—air bubbles produced in modified water pick out metallic particles and reject gangue particles', which statement he discusses in the following part of his testimony. Are you in agreement with the conclusions there drawn?"

A. I think this is correctly stated.

X Q. 557. "50 Q. What relation has this phenomenon to flotation concentration generally?

"A. This is, as stated, an expression of practical results, and I think it is undoubtedly true that flotation phenomena are those produced by the air bubbles, and the qualified expression, 'in modified water' covers a number of cases in which the water is
3776 modified, either by the presence of emulsified oil or by the presence of soluble frothing agents, both of which have a general effect of modifying the water and making it possible to obtain more permanent subdivision of air bubbles, which facilitates, and is the underlying explanation of the reason of the mineral froth."

Have I correctly read your testimony?

A. You have.

X Q. 558. Now, we will turn to page 2099 and I will commence to read in your answer to question 71: "The air froths undoubtedly consist of metallic particles which are held and brought up to the surface of the froth by the action of air bubbles, and it is the air bubbles which attach.

"Now, we have a demonstration in those experiments in the glass cell, that the air bubble attaches equally to the unoiled and to the oiled particles of mineral sulphide, so the direct attachment is to be obtained in the application to oiled or unoiled particles. It is not confined to the unoiled particles. It is true there is no entrainment of oil. It is true, but the presence of oil is none the less to be shown, and has been shown in these experiments, which were made in the glass jar, and that is practically allowed for in the last sentence of this statement: 'Fundamental principles air entrainment and controlled affinity of air for metallic particles in presence of frothing agents.' That 'controlled affinity of air' will cover the case of air froth in which notable quantities of oil are used, because it is the presence of the emulsified oil which makes possible, as the
3777 modifying agent, that air rising, and not only is that true, but I am satisfied that the presence of oil in the large number of these air flotation processes operates not only to make an emulsion, which makes lower surface tension, but operates in minute amount in oiling the mineral particles, and that the raising of the air bubble is the raising of the oiled mineral particle." Have I correctly read your testimony?

A. You have correctly read what I said at that time.

X Q. 559. You remember, do you not, that during the Miami trial an experiment was made in behalf of the plaintiff using one tenth of one per cent of oleic acid and producing a fine mineral froth and then 3.6 per cent of oleic acid was added, the operation repeated, and everything sank to the bottom. You remember that experiment?

A. What was the latter part of your statement?

X Q. 560. 3.6 per cent of oleic acid was added to the pulp, the operation was repeated—agitation for five minutes, and at the con-

clusion of that operation when the material came to rest, everything went to the bottom. Do you remember that?

A. I don't recall the details.

X Q. 561. You don't remember that experiment?

A. I don't remember the experiment now. I would not feel sure that I remember at all that that was done. It may have been true, however, that that was done. I don't recall it.

3778 X Q. 562. Now we will turn to the Everson patent, page 607 of the Hyde record and to page 2 of the Everson patent and I call your attention particularly to the sentence beginning on line 105: "Devices and methods now well known in wet separation of ores will be suited to this part of the operation, bearing in mind that the sand and mineral are merely transposed or their relative positions are reversed, because the sand is heavier than the mixture of mineral, oil and acid." Then the following sentence: "A proper selection of devices for this purpose will be apparent to those skilled in the wet separation of ores." Now, do you know what devices were referred to by Mrs. Everson in this patent of hers issued in 1886 as "devices well known" in the United States in the wet separation of ores? Answer directly?

A. Speaking from general knowledge which I acquired of this matter I would say the spitzkasten was perfectly well known. I am not a metallurgical engineer and I might possibly be more specific in my statements had I knowledge acquired from study of the literature on ore dressing; but the spitzkasten was perfectly well known as has been shown by the testimony introduced, that it was known and known by name prior to 1885; and this description here fits perfectly with the possible use of a spitzkasten. So that if it was well known, we have there undoubtedly a form of apparatus which would do exactly what was desired here, carry off the float, leaving the sand separated. And this particular note of Mrs. Everson's, "bearing in mind that the sand and mineral are
3779 merely transposed or the relative positions are reversed, because the sand is heavier than the mixture of oil, ore and acid." That fits perfectly with the use of a spitzkasten. The sand is settled down, is taken off at the bottom and the froth, composed of these ingredients, that is the mineral and oil in presence of acid, by agitation worked into a froth, is carried off, floated off.

X Q. 563. Do you know that any such procedure would be in accordance with the established principles and methods of wet concentration as carried on in 1886?

A. I do not know it in a professional sense because I have no knowledge that is at all accurate of metallurgical practice.

X Q. 564. Now, returning to the Miami record, to refresh your recollection as to that experiment, which you did not remember, turning to page 2130——

A. Of what volume?

X Q. 565. Volume 3. I will ask you to look at the details of that experiment entitled "Second experiment, showing air bubble rejection of well oiled particles"?

Mr. Scott: What is the question? Is there a question on the record?

Mr. Williams: I wanted to give the doctor a chance to read that before I finished the question.

X Q. 566. Have you examined the description of that experiment?

3780 A. I have.

X Q. 567. Isn't that the experiment to which I referred?

A. That is the experiment evidently to which you referred. I have no recollection at the present time of the conditions of the manipulation. I undoubtedly was present in court but I do not recall the conditions of the manipulation and I cannot pass a critical judgment on the result without that illustration of the condition of agitation and other processes.

X Q. 568. The experiment was made in your presence?

A. I presume it was but I do not recall it.

Mr. Williams: Cross-examination closed.

Redirect examination.

By Mr. Scott:

R. Q. 569. Doctor, you referred to the passage at page 1081 of the Miami record, volume 2, the passage which was read to you, and I will ask you if you have any desire to make any comment upon the statements you there made?

A. I said at the time of the Wilmington trial in answer to cross question 671, the question being: "And is not associated with directions representing any definite mechanical structure? A. There are none." I would like to say now that I did not do justice at that time to the Fryer Hill publication. The Fryer Hill publication, if studied very carefully, and it has been illustrated here of

3781 course by the apparatus, and I would like to say now that there are very definite directions with regard to the mechanical structure. In other words, the whole story which we find in the Fryer Hill publication in regard to the circular tank, or receiver, the rotating, hollow tube, the bottom of which tube having attached to it a couple of fans and the whole operation of this, the semicircular doors which are attached, hanging vertically at the beginning, afterwards raised, shows quite a definite statement of mechanical structure. In other words, the mechanical structure was quite sufficient and complete there to allow the reproduction of the Fryer Hill device; and that has been reproduced and operated, based entirely upon that information.

R. Q. 570. A passage was read to you from your testimony in the Miami case occurring on pages 1059 and 1060, and in that connection will you state whether Everson disclosed more than one method of concentrating ores?

A. This method which is under discussion and consideration, to which the questions and answers were given on page 1059, had en-

tire reference in that first instance or first illustration of Everson with regard to the mixing of acid with oil and then after that mixture had been made completely, working up the ore—that mixture had been made complete, working up the ore; and that was specified
to be a process of washing out the gangue; and the quantities
3782 there given show that it was a process for eliminating the
gangue and leaving in a pasty mass the supported mineral. That process I have characterized in my testimony in this case as a different process from the froth raising process and not involving froth raising. And I have illustrated in this case the second form or second process of Everson in which petroleum or a petroleum particle was used, and in which the Fryer Hill apparatus was made use of and also the cataract machine was availed of to illustrate the second step of the Everson process, quite different. And in the beginning of my testimony in this trial I endeavored to classify the processes of operation and in that classification I put the first instances of Everson and second instance of Everson in totally different categories.

R. Q. 571. A passage was read from your testimony in the Minerals Separation v. Miami, the passage relating to the Criley and Everson publication which appears on page 1083, volume 2, of the record in this case. In connection therewith I would ask you what if any inference you draw or obtain to base upon the use of the word "scum" in that Criley and Everson publication?

A. The Criley and Everson publication, as I have also in connection with testimony in this case mentioned, contributes only a picture of results of the account given in the Fryer Hill publication. That picture of result is—or rather it contributes merely a picture of result with continuous methods because it gives so little account of the
general sequence of steps. But then, it says, "This acidulated
3783 water was then mixed with the mass of oil and ore. A thick
scum of sulphurets rose to the surface and was skimmed off leaving the hitherto black ore as white as snow." I have heretofore illustrated that the word "scum" was synonymous with "froth" and I have also drawn attention several times to the fact that the words "froth" and "scum" are constantly used as synonymous in the literature of these patents, and particularly in the patents of the plaintiffs.

R. Q. 572. You have referred to the use in the Kirby patent of a solution of bitumen and kerosene. Does Kirby refer to the use of anything else besides this mixture?

A. Yes. In Kirby's patent we have the statement on page 2 of the patent: "Kerosene alone, for example, may be used with most ores to take out the sulphides, provided the gas is used as stated to cause the flotation of the kerosene coated particles." That means that you can use kerosene if you supplement it with the use of a gas as is described by him in detail here on the page preceding; but, on the other hand, he says it is the bitumen which, dissolved in the kerosene, gives the decided adhesion to enable him to separate the pulverized chalcopyrite. And therefore, as I understand it, he meant to say that if this bitumen in small amount is dissolved in kerosene you have a distinctly more efficient frothing agent and

selective agent, if it can be called; but if you supplement the use of kerosene taken alone by the use of a gas as in the second step,
3784 you need not use the bitumen, you can use the kerosene without dissolving the bitumen. I have tried both ways. I have used kerosene repeatedly in the Kirby experiment and I have used a certain Trinidad asphalt, a type of bitumen, in the amount there mentioned, five per cent with kerosene, and attained results in both cases.

R. Q. 573. A number of passages in your testimony in the case of Minerals Separation vs. Miami were read to you. Do you desire to comment upon any of the matters there presented? The first one was on page 1170, X Q. 1104. Was there any explanation or comment you wish to make? If so, you will be given an opportunity to discuss it if you want to?

A. I do not care to go into the details of the question about the surface tension. I would merely say that what I stated there is very much less of an explanation—a very much less perfect understanding of the physical phenomena than we have arrived at now. Undoubtedly the effect of surface tension exactly as stated there exists, but the way in which lowering of surface tension is followed by the strengthening of the film once produced by the increased viscosity given to it under the conditions of practical working has been more fully developed since the date of that Miami trial; and my explanation given there I would not consider as at all a full explanation of the theory. The theory has been dealt with very fully in this trial and I have a clearer view now of what takes place in the formation of a mineralized air froth than I had then, although I do not
3785 feel that I made a gross misstatement at that time.

R. Q. 574. You have heard the testimony given about the operations of various films using quantities of oil ranging upward—I think the highest so far was the Arthur plant of the Utah Copper Company where something like 86 pounds of new oil were added per ton of ore. Will you compare such operations with the processes described in the Everson patent and the Kirby patent and the California Journal of Technology?

A. These processes involve as the same step mentioned in all of these publications, the thorough agitation. Now, the thorough agitation is one very deciding element in the determination as to the amount of oil used in an operation. In other words, the necessary amount of oil to produce a mineral-coated froth is a function of several elements, one of which is this agitation. Agitation being one; the richness in mineral sulphides being another; and the dilution of pulp being the third. Particularly in the case of—particularly on the question of agitation I would like to say that if we provide sufficient agitation the large amount of oil can be entirely handled, entirely brought into the condition of a coating film of the additional air bubble supply, and that oil coated film then, as the next step, condenses on its surface the mineral sulphides, strengthening the film, making it more stable because of the increased viscosity. And this takes place with the small amount of oil or with the large

amount of oil, the main deciding function (factor) there
3786 being increased agitation. So that, in principle, it is not different from what was done with 17 per cent of oil in Everson or with the nine per cent of oil I tried in the Froment test tube experiment, or with the smaller amount of oil used in the Froment machine or with the 25 per cent of oil used in the Kirby. In all cases, if we provided the agitation, we accomplished the production of the oiled air bubbles which constitute the froth. These, as I say in turn are stabilized and give us the mineralized froth, which is the new product in all cases.

R. Q. 575. It has been testified, as I think you remember, that the agitation was not at all altered when these large quantities of oil were used. How do you explain that?

A. The agitation is quite abundant in all of the operations that I have seen here to accomplish the formation of a froth which takes up all of the oil in the form of oil film, and I don't know in what degree agitation is controlled or modified to respond to different amounts of oil in large practice; but as far as I have seen illustrated in the illustrating experiments there was no difficulty at all in handling 25%—the 25% of Kirby or the amounts that were used in the Everson with the ordinary agitation there shown.

R. Q. 576. Did you see the experiment performed by Mr. Dosenbach in which he used something over 1% of oil and agitated the mixture and formed a froth, and then agitated again and caused the mineral to sink—to break up the froth, and after doing
3787 that two or three times, finally sank the mineral and separated it as the Cattermole granules in an up-cast?

A. I saw that experiment and watched it very closely, and I have given quite a little consideration to what has been done there and what the results are and I think it is an extremely instructive experiment. I think it is an experiment that goes very clearly right to the heart of the questions which are involved in these patents, and particularly in No. 835,120. The first was to use 1½% of oil, as the statement was made at the time, and the vigorous agitation in the Gabbett cone mixer, using the baffles, too, in the circular cells, and that the speed of revolution was 1,450 revolutions, as stated by Mr. Dosenbach at the time. That produced in six minutes' agitation, which was carried on with this rotation of 1,450 revolutions—That produced an excellent mineral froth, which was allowed to come to rest and examined. Then, with that froth in which the oil was completely taken up with the oil film of the air bubbles, and which had been accomplished by the entraining of air,—and as this rapid agitation has been frequently described by the beating in of air, so that it was subdivided minutely, and these minute air bubbles were coated by reason of this agitation with the oil, and they had taken up the mineral and caused an excellent mineral-coated froth, which was quite recognizable as such. Now, the sole step which was taken next was to change the speed of rotation. The baffles were not taken out in this case; it was found that leaving the baffles in and

3788 merely modifying the rotation so that we had a different style of agitation, an agitation at 300 r. p. m.—I watched it very closely—and that style of rotation had the effect of discharging and eliminating the air which formed the froth from its combination with the oil and the mineral. Now, that agitation continued for six minutes, and at the end of that slow rotation, and the baffles acting less clearly and less sharply, because of this slow rotation, they did not disturb the rotating mass very greatly—at the end of that period of rotation the contents of the cylinder were allowed to come to rest, and we observed no froth on the top, but on the contrary, the oil set free from its contact with the air, and the mineral set free from its contact with the air, had agglutinated and formed the sinking agglutinated mass of sinking mineral, which is pronounced the Cattermole effect. Next the speed was brought back again to 1,450 revolutions by changing the connection, and it was agitated for one minute. That one minute of supplementary agitation again reproduced the froth, because that agitation at the high speed again entrained the air and subdivided it finely and allowed the oil to spread itself in the air film again and to pick up the concentrate mineral, producing the mineralized air froth. I should say that that was again changed, and rotated at 300 revolutions, and granules were formed, and they were taken off finally, five minutes being used for the second slow agitation. I think this experiment is extremely illuminating, because it shows that the production of the
3789 mineralized air froth and the production of the Cattermole granules, using the same amount of oil, the same vessel, everything being absolutely the same, with the sole difference of the type of agitation, is the key to the situation, and that the statements, therefore, in patent 835,120 in regard to the new phenomena produced by lowering the percentage of oil relative to ore—I think are based on false reasoning. I think it has been built up there on mistaken premises, and I think this experiment, if studied carefully, shows that fact.

Recross-examination.

By Mr. Williams:

R. X Q. 577. I understand from the evidence that you have just given that you adopt these large scale operations which have been testified to at the Butte & Superior plant, the Chino, the Ray, the Utah Copper Company Arthur plant and the Utah Copper Company Magna plant as representing the prior art. Is that correct?

A. They are entirely in consonance with the prior art, with mechanical improvements, but no new principle added.

R. X Q. 578. And what prior art do they represent?

A. The prior art developed by Everson, Froment, and Kirby.

R. X Q. 579. And which is represented by the operations of the Butte & Superior Copper Company?

3790 A. There is no new principle, other than that which was already developed by the Everson second process, with some additional light thrown upon it, but no new principle added, by the

Froment. I should say that the Everson alone gives all the principles involved in the present application.

R. X Q. 580. But I am concerned, not with principles, but with operations. What prior art patent is represented by the operations of the Butte & Superior mill which have been described in the evidence, with twenty and a trifle more pounds of oil to the ton of ore, carried on in the Janney machines?

A. There has been no description of the Janney machine in the prior art, that is true. There has been no description of the various mechanical appliances, but the principles of the process which is there applied by improved mechanical devices, has all been disclosed in the Everson patent.

R. X Q. 581. But these operations of the Butte & Superior mill with one per cent and a trifle over one per cent of oil, what prior art do they represent?

A. Everson and Froment.

R. X Q. 582. Everson and Froment?

A. Yes, sir.

R. X Q. 583. How do they repeat Froment?

A. Froment used small quantities of oil as described in his description, one per cent and two to two and a half.

R. X Q. 584. We will take the Froment patents. Do the Froment patents describe 1% of oil?

3791 A. No.

R. X Q. 585. We will take the Everson patent. Does the Everson patent describe one per cent of oil?

A. It does not describe any per cent. It gives an example, which, reckoned out, makes 17%, but it does not describe any per cent.

R. X Q. 586. So that it only describes an operation with 17% of oil?

A. That is the only example.

R. X Q. 587. Now, we will take the operations of the Utah Copper Company Arthur plant with one per cent of oil and a trifle over. What prior disclosures are reproduced in those operations?

A. I have the same answer as with regard to the Butte & Superior, which you spoke of. We have the principle already stated which is involved there, with mechanical improvements, and the per cent of oil is not limited in that statement of the principle in Everson.

R. X Q. 588. Then you stand upon them as representatives of the Everson, reproductions of the Everson?

A. With the mechanical improvements and the experience gained by the working out of those principles.

R. X Q. 589. With improvements and knowledge and experience which have followed the introduction in this country of the process of the patent in suit, isn't that right?

3792 A. Yes; there has been an immense mass of experimental work done in all the mills, which contribute to it.

R. X Q. 590. And as to the other plants, the Chino and the Ray, I presume the same thing applies?

A. The same would apply.

Redirect examination.

By Mr. Scott:

R. Q. 591. As regards all of these plants just referred to on cross-examination, the Butte & Superior, the Arthur, Magna, Chino, Ray, which have been operating with quantities of oil upwards of one per cent., I would ask you, considering this as a process, as the application of principle regardless of the particular forms of the mechanism used, whether or not you find any principle or operation in practice in these mills which is not set forth in the Everson patent, the Froment British and Italian patents, and the Kirby patent, and the articles in the California Journal of Technology?

Mr. Garrison: I object to the form of the question; it is entirely improper to ask an expert such a question.

Mr. Scott: The question merely calls for whether he finds in these operations the application of principle not disclosed in this various literature. The question was objected to as improper, but
3793 there is no reason given. That is all I can say to the objection in that form.

Mr. Garrison: I think it is obvious, if the court will indulge me. The counsel has simply formulated what he desires to have testified and the witness was left simply to say yes or no. It was entirely the evidence of counsel.

The Court: Objection sustained; you can change the form of the question.

Mr. Scott: Do I understand the objection to be that the question is leading?

The Court: I think it is leading; that is to say, it is your statement to which he is to give a yes or no answer, merely to assent or dissent from your statement.

Defendant excepted.

R. Q. 592. State, Doctor Sadtler, what you consider the essential steps and the essential ingredients used in the process as practised by these various mills named in my previous question—what you consider the essential operations and the essential substances used.

A. The essential conditions of the illustration of the principles which have been given in the prior art are, the presence of the finely ground ore with the addition of a sufficient amount of water to make a freely flowing ore pulp, and the addition of oil which oil has a selective action, as defined, a large number of which are enumerated by Everson; and then thorough agitation, which will bring
3794 about a commingling of these ingredients. Under those conditions we have, following the laws of physics, certain results, which results are first, the formation of fine divided air bubbles coated by the oil film, and it has been shown that that amount of oil may vary over wide limits; those oil coated bubbles have the power of condensing into their film metallic sulphides, mineral particles of that type, and of rejecting the gangue material, and the agitation provides the conditions for a separation, by reason of the formation

of this mineral coated froth, which, flowing into the spitzkasten will separate, and is then by mechanical means taken out and afterwards treated. The tailings can be retreated, which is already indicated in the early literature; retreatment is spoken of in that California publication, and also in the others, and therefore we have all the conditions pointed out for following a successful operation in practice. Many mechanical devices had to be introduced, and very considerable experience had to be gained as to how it would work to the best advantage in the application of these principles, but the principles are all there, and the practice of these mills has not added anything that I can see to the understanding of the principles stated.

Witness excused.

3795 THOMAS A. JANNEY, recalled on behalf of defendant, for further

Direct examination.

By Mr. Scott:

Q. 1. Mr. Janney, have you recently conducted any mill operations with quantities of oil out of the ordinary?

A. Yes, sir; on April 29th our plant ran for eight hours, and I used 323.78 lbs. of oil per ton.

Q. 2. Was this test conducted under your personal supervision?

A. It was.

Q. 3. And in your presence?

A. I was there the largest portion of the time.

Q. 4. And to whom did you give immediate charge of the operation when you were not there?

A. Mr. Rex Sutherland.

Q. 5. Is Mr. Rex Sutherland here?

A. He is.

Q. 6. Who co-operated with Mr. Sutherland in this operation?

A. Mr. George Taylor and an operator whose name I have not got.

Q. 7. Is Mr. Taylor here?

A. Yes, sir.

Q. 8. In the taking of samples who participated?

A. Mr. Meading, who is our head sampler, had charge of
3796 the sampling, and he himself took the moisture samples of the feed going to the machine, with the exception of two samples which were taken while he was at dinner, and those two samples were taken by Mr. Mower.

Q. 9. Are Mr. Meading and Mr. Mower here?

A. They are; and Mr. Mower had charge and actually took all of the samples for oil analysis and metal analysis and the tonnage samples.

Q. 10. By what you have said it seems that he took all of the samples except the moisture samples, and he took two of them?

A. Yes.

Q. 11. And that the others were taken by Mr. Meading?

A. Yes, sir.

Q. 12. Now as to the assaying of all these samples of the mineral first; that is, metal and insoluble, who performed that operation?

A. Mr. Martin, our chief chemist.

Q. 13. And is he here?

A. He is.

Q. 14. Did he do this personally, this assaying?

A. Yes, sir.

Q. 15. You said duplicate samples were taken; what was the second sample for?

A. One sample was taken for oil analysis and the other sample was taken for metal analysis.

Q. 16. That is the one you just referred to that Mr. Martin assayed?

3797 A. Yes, sir.

Q. 17. Who made the assay for the oil?

A. Mr. Clauson, our oil chemist.

Q. 18. Is he here?

A. He is.

Q. 19. Now, will you describe first the apparatus in which this operation took place, stating whether it was part of the mill equipment, or what it is?

Mr. Garrison: At an appropriate time, if your honor please, I desire to introduce an objection. I do not care to object until counsel has fully gotten upon the record the equipment used or whatever the thing is, but I desire to warn the witness not to answer if he is asked to describe the experiment until I have had opportunity to interpose my objection.

A. The machine that I used is known as our No. 1 retreatment plant. This plant consists of two emulsifiers——

Mr. Scott: I offer the blue print produced by the witness in evidence, the same being entitled "Flow Sheet of Concentrate Flotation Plant, Arthur Plant, Utah Copper Company."

Mr. Williams: We reserve the right of objection, as this it seems will facilitate the testimony, so it would be well to have it before us.

Blue print admitted in evidence marked Defendant's Exhibit No. 219.

A. The plant in which this run was made is known as our
3798 No. 1 retreatment plant, and consists of two mechanical emulsifiers followed by thirteen frothing cells.

Q. 20. I wonder if you could not point that out on the blue print so that the court can more readily understand it. It is rather small.

A. In this particular test——

Q. 21. One minute, please. Are these two mechanical emulsifiers the two cells at the left of these—of this series under the words "No. 1 plant"?

A. They are illustrated by two circles. It says, "two emulsifiers in series."

Q. 22. With that placard marking them upon the diagram?

A. Yes, sir. In this run I endeavored to make two products, one was a tailing, which was sent to waste, and all of the froth from the 13 cells was considered a concentrate. That is we did not circulate as illustrated by this flow sheet. This flow sheet represents our operations as we run from day to day.

Q. 23. The "middlings to elevator" part of this diagram did not figure when you were carrying out this test?

A. That is it, yes, sir.

Q. 24. The material just simply went straight through the 13 cells and out and that was the end of it?

A. Yes, sir.

Q. 25. Froth taken off and tailings discharged?

A. Yes, sir. Previous to the time that this test was made,
3799 in the regular operations, we circulated a middling and that middling went back to the two Dorr tanks and thence back to the flotation cell. 24 hours before this test run was made I cut out the circulating in the hope that there would be no trace of oil in the Dorr tanks when I started this run. But I found that when I started the run that there was a small amount of oil in the feed.

Q. 26. You mean as it came before you at the end?

A. Yes, sir, as it came to the flotation machine.

Q. 27. And how much was there?

Mr. Garrison: I object now to any testimony of these details of the experiment. I have no objection to their laying the foundation, the questions as to what that experiment disclosed, but I do not want to be prejudiced by evidence which I feel we have a right to exclude under our objection.

Mr. Kremer: I think we all understand the situation. I think Judge Garrison might make his objection, state his grounds at any time so we might know what they are.

Mr. Garrison: If your honor pleases, this gentleman has testified that on the 29th of April, during the course of this trial, in fact only a few days ago, being a manager or mill superintendent—I have forgotten just which—he was, of one of the plants of one of the allied companies with the defendant—has, during a certain part of the day run a test. I cannot conceive under what head of evidence such testimony could be admissible. The utmost limits to which
3800 courts have gone, so far as I know, in permitting testimony of experiments not made in court, not made under the supervision of both parties, is by experts to illustrate or substantiate from those their testimony. It is a very grave question, in regarding the opinions of the courts, including the Supreme Court of the United States, with respect to such testimony, as to whether it should not by the nisi prius court be excluded, because the ordinary form that is used by counsel in objecting to testimony by reason of its orderliness is quite often not carefully considered. We object because it is "incompetent, irrelevant and immaterial."

I have always considered that immaterial evidence was evidence the weight of which was so slight that it had no materiality. Now, the Supreme Court of the United States and other courts in this

country, in dealing with the situation of experiments carried on by a party as an experiment and testified to by them, have practically said that such things are immaterial; they should receive no consideration.

But it is a waste of time to discuss that further than the sidelight that it casts upon the objection I am making. This gentleman is not there as an expert, he is not going to testify as to Kirby and Everson and Froment and so forth. He is a practical man, he is a fact witness and nothing else. I think it is the third time you have been on the stand.

The Witness: Twice.

Mr. Garrison: The second time he has been upon the stand to testify with respect to operations, at his mill, as a fact witness.

3801 Now, isn't it most ridiculous—now, is it not a most remarkable sight, during the course of a trial—and I am going to use a word now in no offensive sense—evidence is manufactured and brought in. He goes off to manufacture this piece of evidence. He makes it and produces it. It is a fact question. He brings it in here with no possible opportunity for us to have any such relation to that fact as gives us a chance to test its verity. We will have nothing whatever except things written down upon a piece of paper.

Now, it is bad enough if the rule is held to be extended to experiments made out of court during the course of a trial by experts; but to a certain extent, the situation is alleviated there because necessarily he has to tie these things into a theory; and, if his theory is unsound or his theory is one of those rapidly changing theories, as all theories in this case seem to be, it is not of much materiality, it doesn't hurt anybody very much, because what they think today they don't think tomorrow and we don't much care on what experiments they base their conclusion. But this is not this situation. This is a fact. This gentleman here is a fact witness. He is going to testify to facts. Now, I respectfully submit that in the whole course of the production of the body of law and of evidence in this country, I doubt whether you can find an instance where courts have countenanced the making of facts during the course of a trial.

3802 How is it relative to any issue in this case? The issue in this case is as to whether the patent in suit is valid and whether the defendants have infringed it. They have confessed infringement in their stipulation. Therefore, that issue is out of the case. How can this possibly—this fact that this witness made on the 29th of April—cast any possible light here on the question of whether the patent in suit was valid when issued? It cannot. Therefore under no law that I can see, that this case has developed, can this testimony be relevant or material or competent. I object to it as incompetent; I object to it as immaterial; I object to it as irrelevant.

Mr. Scott: Now, in the first place, as to the time of this operation. I fail to see that that has any bearing — the admissibility of the evidence. The investigation of a fact sheds light upon the fact regardless of whether the investigation is made during the trial or before the trial. We have had many experiments here already that

may have been devised during this trial—doubtless they were. It is entirely immaterial. They are accepted as a means of shedding light upon the question at issue; and I cannot conceive how the question of time has anything to do with it.

Now, as to its having no bearing upon any question at issue here. It has the most direct bearing. The patent is based upon the assumption and has for its only foundation the proposition that there is a different phenomena taking place when the amount of oil is reduced below a certain alleged and fictitious critical amount. Now no
3803 one can deny that this experiment will shed light upon that question; that it will show that this fictitious amount is an absolute myth.

And as to the presence of the other parties at this experiment, the books are full of cases to the effect that it does not run to the admissibility of evidence at all. Of course the court in considering any evidence doubtless always will take into consideration the circumstances under which the experiment, regarding which evidence was offered, was performed; but this is a matter of credibility that has nothing to do with the admissibility of this evidence.

And, furthermore, here three or four days ago when we started to prove an operation similar to this one to which this witness will testify some objection was made on the ground that the other parties were not present. After some discussion we invited them to be present, to compare the operation. The offer was accepted and the acceptance of it is in the record and we have proceeded in view of that state of affairs, and we have these witnesses here this morning. We have all of the necessary witnesses to corroborate all of the details of the operation. And as far as the Supreme Court of the United States and as for there being dozens of decisions, or some such number as that, to the effect that the experiments by experts should not be considered, I can point to any number of cases in which the decision is hinged upon precisely such experiments. They have always been considered. I doubt if we will have any difficulty in bringing in cases upon that point.

3804 Therefore, I see no legal objection to this witness proceeding with his testimony. The operation to which he testifies will be repeated under our previous offer and thus the only objection, even to the credibility of the operation, is removed, and I maintain that no objection dealing with the admissibility of the evidence has been offered.

Mr. Garrison: Now, if your honor please, Mr. Scott has with utmost frankness disclosed the purpose of this testimony. He has said and of course I do not have to concur in his construction, but he has said our entire patent depends upon a certain statement with respect to phenomena. He proposes by this witness to prove that the patent rests upon a falsehood. This evidence, if admitted in this case as evidence, he says will be decisive positively of the entire case. So that we are faced with a critical stipulation which, according to our opponents, our entire case is to be determined on whether this witness can testify what he did on the 29th of April and the results thereof.

Now, this phenomenon is one which requires for a determination

expert knowledge of exactly what has been done and the results. We are so saturated now, after three weeks of this trial, that we know that the result, the method of operation, the mechanical principle, the nature and character of the froth, the position of the mineral, the situation with respect to the gangue, the action and subsequent appearance or disappearance of the oil, the action and subsequent appearance and disappearance of the acid, are all things of importance that cannot be exaggerated.

3805 Now, we cannot see any of these things. We are going to be faced with statements by this witness that the critical things which make this experiment, made where they wanted it to be made, were present, and how can we possibly disprove whether they were present or not. The only set of eyes, the only mouth, the only brain, that can testify is this gentleman. He is here proffered by the other side, and of course it is without any question therefore to be assumed that he will say that the things were present which are determinative, so Mr. Scott says, of the issues in this case.

In other words, we have got this proposition: That during the course of the trial with respect to a fact, a witness may be permitted to depart from the neighborhood of the court room, produce a certain set of facts, come in and testify to them and thus dispose of the case absolutely! If that can be permitted, if that is permitted, it does seem to me that all of the rules of evidence that it has taken centuries of care to build up in order that justice may be administered, with due respect to the opportunity to test the proof, are done away with.

Mr. Scott: One more point I would like to make, your honor.

Now, this same objection, identical in substance and form, was made the other day, and an additional objection was made that the testimony then offered was hearsay. Now that was fully considered and after the noon recess I addressed myself to the court for

3806 the purpose of getting a complete understanding of the situation and I think I am correct in saying that the court's ruling in excluding this testimony was based simply upon the ground that it was hearsay, and upon no other ground.

The Court: Yes, but the court did not commit itself to any other proposition at that time. Even if it did, if the court was wrong at one time it wouldn't have any hesitancy in changing at another.

Mr. Scott: I did not intend to make that argument.

The Court: Here is the proposition as the court sees it: Under proper circumstances, I do not think it is an objection to an experiment that the other side have not had an opportunity to be present, but experiments are of value, probative value, in any case, if they are had and made under the conditions of the act or fact which they purpose to illustrate. Now, this patent has been issued some 12 years, and you are having experiments today, as I observed the other day, in the light of 12 years' development and four remarkable years—or years of remarkable development of the process of this patent in suit. Now, are they under the conditions as they were when this patent was issued, when this discovery was made.

Mr. Scott: They are the conditions with the quantities of oil that were stated were in the prior art precisely. These experiments he

tried run up to about 16 or 17 per cent, I think, or as a matter of fact, three hundred and twenty-some pounds. The same
3807 quantity of oil that Everson mentions, approaching the quantity that Kirby mentions, far in excess of the quantity mentioned in the California Journal, and far in excess of Froment's quantity, and it is upon the presumption that the improvement set forth in this patent is a new process, growing out of the reduction of the amount of oil named in the prior art. Now, we conducted these operations with exactly the steps described in the prior art—nothing to it except the powdered ore, the water, the oil, the agitation and the froth, and those are the things that are mentioned in the prior art, and that the prior art tells us how to do, and we have used this quantity of oil, the quantity mentioned in some of the prior art documents and beyond that mentioned in others, and we come here before this court confronted by this decision against us based upon the existence of a so-called critical point which marks of this patent from the prior art. We produce an experiment in which we use the quantities of the prior art with the step prescribed by the prior art, a quantity far in excess of that so-called critical amount; and I fail to see how the experiment can be immaterial, how it can have too little weight. It meets the issue squarely. It does what the patentees say cannot be done. It does what the prior art inventors said could be done.

The Court: Well, if it wasn't being done in those days and couldn't be done, if nobody knew how to do it and now, as you say, after all of these experiments you develop it is seen that it can be done, ought to have been done then, is it material?

3808 Mr. Scott: We follow the exact directions of this prior art, and these patentees are no more warranted in coming before this court and saying that a given person is following their directions than the other patentees are in coming in and saying you are following my directions. The only respect in which anybody ever followed the directions of this patent in suit in a respect not shown in other patents, is in the practice of economy. And other patentees and inventors have set a sufficient amount, they have said as low as one per cent, and then this patentee happens to make a lucky guess that this process could be made successful, that it could be done with less than one per cent.

The Court: It is like all other attempts to solve a problem. Others had worked on it, of course, and all, so far as the evidence shows, had practically failed in producing the particular froth that this patentee did. In due course of time these people—yes, perhaps by a lucky guess or a lucky accident—took the step and made possible, perfect what before they were simply striving to do.

Mr. Scott: Our position upon that, your honor, is that these patentees did not tell us how to do it with less than one per cent. They said: "Do the same thing that all of these prior inventors did" and guess that you could do it with less than one per cent.

The Court: Well, at any rate we are coming pretty close to the end of experiments that the court will receive. I will give you until two o'clock, both of you, to bring in the au-
3809 thorities on this question of experiments. The patent law must be full of it. You have mentioned them several times, but I haven't seen any authorities on these experiments. Let's have them at two o'clock.

Whereupon an adjournment was taken until 2:00 p. m. Friday, May 4th, 1917.

2 p. m.—May 4, 1917.

Mr. Garrison: If your honor please, your honor will recall that in the early stages of this case, when the defendant began the introduction of present day operations, an objection was interposed that it was not relevant or material to any issue to be tried in this case. At that time I presented to your honor a series of authorities in England and in this country directly in point, the point being that where the question of validity is involved, and it depends upon the state of the prior art, no testimony is admissible with respect to the prior art unless it is given from the standpoint of the prior art, and the testimony which refers to the prior art in the light of later developments has but one purpose, and that is to confuse the issue and make it difficult for the court to see what otherwise would be simple. Mr. Scott, representing the defendant, at that time met the challenge and stated that he would connect these later day operations with the prior art, and would show that they were demonstrations of the prior art.

This test about which they purpose calling this witness, performed within a week, does not purport by any of the testimony given
3810 by this witness—and by that alone can we test it now—to reproduce the conditions of the prior art. This witness is not proffered as an expert with respect to the prior art.

I find that the cases have had to deal with the conditions existing prior to the rule which now prevails respecting the trial of patent cases in open court. Of necessity courts in the past have had placed before them for their consideration all of the testimony taken before the master or examiner in chancery who took the testimony, and therefore the courts dealt with the evidence of experts with respect to tests from the viewpoint of the testimony that was already in the case, and the question was what should be done with it. Therefore it is not remarkable—in fact it would be very remarkable were it otherwise—that we do not find any law with respect to the admissibility of the evidence. We do find expressed in the disposing of the evidence what indicates the duty of the Nisi Prius Court under the modern rule, under which testimony is taken in its presence.

As a basis for what I shall say I refer to 83d Fed. Pages 696 and 697: "The complainant has endeavored to demonstrate that this testimony is untrustworthy and his expert has introduced a series of experiments to show that the method described by the defendant is incapable of producing a seamless cap. That complainant's expert should prove the defendant's methods inoperative is not surprising.

An experience of 14 years in patent litigation has convinced the court that when an expert endeavors to prove that his adver-
3811 sary's machine will not work, he is always successful. It is much easier to make a machine that won't."

177 Fed. 717, page 721. The court said: "I give no weight to complainant's experiment made in the absence of the defendant; such attempts at the making of evidence are not to be encouraged."

165 Fed. 806-11. "We disregard altogether the reports of tests made apparently by a skilled operator, some of them in the absence of complainant or of doubtful interpretation and in all so few as to be valueless."

179 Fed., 701—at 77. "The record discloses attempts to demonstrate actual identity, but these are not produced in such shape as to avail the appellant. The courts place little weight on ex-parte demonstrations in any case, but especially is this true in regard to experiments with chemicals."

Now, keeping in mind that all these rulings were made where the evidence was already in the case, we find that even there, in dealing with experts, the courts have said that they disregarded their testimony. Now, if we disregard testimony, it must be because it is either irrelevant or immaterial or incompetent, and I assume that this was disregarded because it was immaterial, because it had no weight.

However, the main grounds for the exclusion of this evidence, it seems to me, is furnished by the facts that are incontestable. Its only possible relevancy would — as to the matter of validity; there will be no pretense that it carries any weight whatever as to the question of infringement. Now, what materiality, what relevancy can a
3812 procedure at the Utah plant, carried on in a machine invented three or four years ago, with materials not those of the prior art, in a manner not disclosed by any procedure in the prior art—have upon the question of validity in the case at bar. Without any extended discussion, we are advised from the view point of the defendants, as testified to by their experts, and the only one who has dealt with the prior art—Froment, with his (according to them) olive oil and the test tube; Mrs. Everson with her bread kneading process and her other process by which the position of the gangue and the metal is reversed and the metal is washed off by methods well known in the wet separation of ores; and Kirby with his gentle agitation and elevation of an oil layer with the mineral clinging between the oil and the water and separating, by the novelty of his invention, which is the injection of oil and air—all are illustrated by methods in which none of those methods are used, none of those procedures are carried out, and a totally different result is achieved.

As to how far courts will permit experiments, I think without exception one in limine procedure is required of the person presenting the experiment, namely, that the conditions under which the experiment is produced are identical with those that they pretend to repeat. I have not attempted to bring with me the citations or quotations from the innumerable cases which hold that. What our position would be were these gentlemen to proffer through the mouth of this

witness testimony of what he found to happen in a test tube
3813 in Utah in the attempt to put olive oil and sulphuric acid and shake it up, according to the way he read that Froment patent, I will not take time to discuss. What would happen, similarly, if he told us what he did in his room in his home in Utah, by kneading the mass, according to Mrs. Everson, or by taking some apparatus well known in the wet separation of ores and following her second practice—or if he constructed a Kirby machine and operated it in his own room and told us the results—I will not say what position we would take toward those; but we think these gentlemen have themselves laid the ground work for showing that what this gentleman proposes to testify to is in no way, identical with those which they purport to represent—there is no possible basis in the law of evidence or the law relating to the trial of issues in patent suits to justify or vindicate this evidence, and there is an entire failure of it in such evidence, and I think the witness has already testified, when he was identifying his flow sheet, that these were Janney machines, and the evidence is already before you that they are a matter of three or four years of age; so that it is demonstrated before your honor that this can not possibly be any reproduction of conditions existing at the time of Froment, at the time of Everson, or at the time of Kirby, and if they are not, then there is no possible basis whatever for the introduction of this evidence in this suit.

Mr. Scott: First, as to the identity of conditions, of course we all admit that the conditions of any incident must be reproduced with substantial identity. I never knew of any requirement that
3814 the impossibility of absolute identity be complied with. Now, the only question of any importance bearing upon this matter is the mechanism employed. The patent in suit discloses and the complainant's testimony is that the apparatus there used was known 20 years before the patent was applied for or the alleged invention made. It is in evidence that all kinds of agitating apparatus were in existence before the prior art documents upon which we rely. That is the identity. We used agitators in this process before the court. It is not a question of mechanism. The process involves the mechanical step of agitation. The only elements involved in the process are these: the powdering of the ore, the mixing of the ore with water, the addition of oil and the agitation. This completes the whole process from beginning to end, and no question of identity can come up as far as to the process. That is the process as shown to the court, the apparatus was all known at the time.

Now, the authorities that Mr. Garrison has been reading simply confirm what I told the court this morning, that this question of experiments, whether made ex-parte or inter-partes, no matter how performed, merely goes to their weight and has nothing to do with their admissibility. Every case read by Mr. Garrison enforces this point. The point has never been analyzed in patent cases, so far as I know, because these experiments have always been received, and if we look into the patent cases all we see is the analysis by the court of the experiments with a view to judging their weight as evidence.

In the general law, of course, the instances are many where
3815 these cases have been analyzed and there is one case in particular that I have a note of. That is Berg v. Chicago & Rock Island Railroad Company. In this case the plaintiff's children—two children had been injured on defendant's railroad tracks, and the defendant without notice to the plaintiff made certain tests to show that the theory of plaintiff as disclosed in the pleadings was untenable, and upon that state of facts the Supreme Court of Iowa commented as follows: "Defendant made certain tests without notice to the plaintiff. The court admitted proofs of these tests over the objection of plaintiff." The court goes on to say: "We think these tests were proper and if fairly made the facts disclosed thereby would be of great value in reaching a conclusion. We cannot adopt appellant's view that it is an attempt to manufacture ex-parte testimony. Instances are without number where, pending litigation, the parties have made tests, measurements and trials relating to facts in dispute, and they have been regarded as co..apetent and as a quite satisfactory class of evidence upon questions of fact, and we are not favored with the suggestion against the reason of such a rule. Upon the question of the admissibility of such evidence, courts have never assumed that it was "manufactured" in the sense in which the term is used in argument. It is not the law that in making such tests, measurements and so forth, the opposite party is entitled to notice in order that he may be present. It is the right of each party in the preparation for trial to take all legal steps in the way of being able to meet the issues of facts by proof, and in preparing for the
3816 presentation of his evidence no notice to the adverse party is required. When they are used——

That is the test—"When they are used the circumstances of their use, including motives for and all the conditions of an unfair or impartial use are matters that may lessen the value of the testimony." That is the end of the court's comments. That is the case of Berg v. Chicago & Rock Island Railway Company, 57 N. W. Reporter, 680, and it is found in the Supreme Court reports of Iowa 90th volume, page 106. In the case of Byers v. Nashville Railroad Company, 94 Tenn. 345, the court says:

"It is next assigned as error that the court excluded the testimony of Henry Mangrum, who, at the request of the company, made an actual test to see whether the train that caused the death could have been stopped after the engineer saw or could have seen the man on the bridge. This witness proposed to prove that he ran the same train on a different day, after the accident, over the same place and bridge; that he had the same number of coaches; that in making the test, as soon as he could, by being on the lookout, see an object standing on the center of the bridge, he applied every means known to him or other skillful engineers, and used every endeavor, to stop his train, and that it was impossible to stop such a train before passing over the bridge; and that his entire train passed over the bridge before he was able to stop it. He further would have testified, if allowed, that he applied his air brakes, reversed his engine, and used every means known to engineers to effect the stop, but was un-

able to do so. This test was made by Mangrum for the purpose of making him a witness and proving the result of the test. This evidence, on objection, was not allowed to be given. The authorities in other states are conflicting upon the admissibility of such evidence, and we have been cited to many cases, all of which we have examined. In our own state it has been held that the evidence of an expert is not incompetent because of an ex parte examination, investigation, or experiment made by him. Nor is such evidence inadmissible because the experiments were made after the suit and trial has begun, and with a view to being used as testimony in the case. The objection in such cases goes not to the competency or admissibility of the testimony, which is a matter for the court to determine, but to its weight and sufficiency before the jury; and especially is this the case where the experiment is made ex parte, and is such that it lies wholly within the power of one party, and wholly beyond the power of another party, to make such experiment. We have been cited to quite a number of authorities to sustain the contention that such evidence is incompetent and inadmissible in cases where the experiment is not equally within the reach of both parties, but we have not been able to find this doctrine sustained. We do find cases, however, holding that, where the experiment is made ex parte, it affects its weight that it was not made after due notice to the opposing party, and giving such party opportunity to be present and see the test applied. That such evidence is competent, but its weight to be duly weighed by the jury, is supported by the following authorities: Boyd v. State, 14 Lea, 161; Lipes v. State, 15 Lea, 125; Railroad Co. v. Ayres, 16 Lea, 725; Railroad Co. v. Champion (Ind. Sup.) 32 N. E. 874; Underh. Ev. P. 201; and other cases in accord. It is uniformly held that in all such tests, to make them competent, the conditions under which the tests were made must be the same as near as practicable. This requirement appears to have been substantially complied with in this case; and, judging from the testimony offered to be given, the conditions of the test were essentially the same as when the accident occurred. We are of opinion the trial judge was in error in not allowing evidence of this test to be introduced, under proper instructions to the jury as to its weight. We cannot speculate on what might have been the verdict of the jury if this evidence had been allowed to be introduced. It was upon a vital point in the controversy. The plaintiff had been permitted to prove by a witness that he had gone upon the tracks, and measured the distance at which a man could be seen standing in the middle of the bridge; and a hot contest was made over the question how far a man could be seen on approaching the bridge, and opinions pro and con were introduced on the question whether it would be possible to stop the train after reaching a point where a man could first be seen by a lookout upon an approaching train. This is the turning point in the case, and the evidence was very conflicting; and for the error of the court in rejecting evidence of this test, properly limiting its weight and sufficiency, the cause must be reversed and remanded for a new trial."

Now, there is a parallel between that case and this case. Here, this patent before the court is based upon an experimental test. Some gentlemen in London, some 11 or 12 years ago, took a little laboratory machine such as we have here, with their knowledge of the prior art, either actual or constructive, and it makes no difference which, although probably actual, with full knowledge of the prior art respecting the quantities of oil which this witness will say he used, and smaller quantities and larger quantities, with full knowledge of those facts, they take this little apparatus and perform an experiment with which they get a froth with less than one per cent of oil, and then they go forth to the world and say: this is a discovery, these people that went before couldn't do this and no man ever did it before.

We offer this testimony to show that what these prior art inventors disclosed could be done when they invented it, could be done when these men in London put this fiction before the world, and that it can be done today. What are the conditions of the prior art that we reproduce? They are the powdering of the ore, which this witness has done in this experiment or had done for him; its admixture with water, the addition of oil in the amount named in the prior art, larger quantities maybe than the prior art inventors named—and the last step, agitation. Here is represented every condition.
3820 He has done it in a receptacle made of iron while some of these prior art people may have made it of wood. It may be that he turned the agitator with an electric motor while they may have used a water wheel. That is no departure from the substantial identity of conditions. And therefore I maintain that there is not a single criticism put forth by Mr. Garrison that will stand the test of adjudicated cases or of reason.

Mr. Garrison: I only want to say one thing, to say that the cases all hold just as Mr. Scott has read from his cases, that the person performing the test has illustrated that the conditions of the test represent and reproduce what they purport to represent and reproduce, in his case a railroad track, same engine, same cars, same place, same bridge. Until they do that, it is not admissible, and so far from their having laid that groundwork, their testimony shows that so long as they use this equipment that they have at this mill they cannot even pretend that they are representing anything that the prior art disclosed or anything that puts us in the position of the prior art.

The Court: The court will consider for a moment what was said when this character of evidence was first offered.

(Whereupon a short recess was taken.)

The Court: This objection seems really to bring us right back to where we were on the day when the defense first offered evidence of what was being done in other plants for while before noon
3821 the objection was based upon the fact that experiments are not admissible at all, and while that ground has not been abandoned since noon—and I think before noon the objection was also made that it was not illustrative of the prior art—all of that was

met by the court's ruling originally when this character of evidence was offered at that time, that it was going to be, as the defendant promised, connected up and shown to be illustrative of the prior art. As I have said before, the proof in this case must be that of the prior art. Mere subsequent developments, improvements, discoveries, will not have weight and properly can have no weight in the final determination of the case. But it is said still that this was the prior art. As far as experiments are concerned, they are subject to both criticism and suspicion. I would not go as far as the cases that counsel has read from, absolutely refusing to consider such evidence altogether, the 177 and 165th and 179th Federal—or that expert testimony before the court is of no value, because it does not seem to me that that is in accord with either logic or principle; it does go to its credibility or weight, and how much the court will give to either to that variety of testimony. It is necessary that the conditions shall be the same of course, or otherwise the experiment is wholly misleading. I suppose every judge who has sat on the bench has had plenty of evidence of experiments brought before him one time or another. The case counsel read from last indicates that,

and also it has been so in this court. Conditions must be the
3822 same. If John Doe was being prosecuted for shooting Rich-
and Roe with a gun at a distance of 500 yards, it would certainly be competent for the defense to come in and show that the gun, by actual experiment, would not carry that far; but it would also be necessary for the defense to show that it was at the same range and the same sort of ammunition, that the gun was held at the same angle or at least at the most favorable angle; for if it was shown that the shot was fired at a thousand yards, the experiment would be worth nothing. I think the court observed in a former ruling as to what can be done today as to experiments is correct, that it all turns on the substantial identity. Another remark the court made was that there is already evidence in this case that the defendant is operating and has operated with more than one per cent of oil specified in the patent, and plaintiff not having explained its position in reference to that—the time not having come—it might be that the plaintiff might claim that such operation could not be conducted with that amount of oil. Certainly, to meet that contingency, the defendant would have a right to show that they can be conducted. Plaintiff might claim that they could not be conducted under any other conditions than the Butte & Superior conditions, and it would be competent for the defendant to show, as corroborative, that they can be and that they are being conducted elsewhere.

Now, this experiment which the defense proposes to put
3823 in evidence is of the same character of regular operations;
I think you might say that it was conducted long enough to bear a semblance to the regular operations which are covered by the stipulation. I think one of the objections raised the other day was that it was only an hour, and hence it could not come within the stipulation.

Having started out upon the theory that the defendant can introduce this evidence as illustrative of the prior state of the art,—Of

course it must be shown by proof; it is not sufficient to claim that is the prior state of the art—The court will not change its ruling now, but as I said before you are getting close to the limit as to the number of these experiments which you will be allowed to show. As Judge Holmes puts it in a Massachusetts case, the court must control that, and not allow them to continue for the length of a man's life, if not for eternity. I can not wait here while you go to Utah and make experiments indefinitely. So this objection will be overruled, but bear in mind that you are getting pretty nearly to the end. I am not prepared to say that counsel has failed—He has not put all his case in in defense yet—to show that these conditions come fairly within the prior state of the art, but I am prepared to say that counsel has a heavy burden on him to show that. Of course I have observed here before that this case is being tried, as far as the evidence is concerned, as though the Hyde case never existed;

but with the presumption of validity attaching to the patent
3824 in suit, and the Supreme Court standing back of that patent.

the defense knows what it has to overcome. So we will allow you to proced, and in the end we will see whether it is, as you claim it is, illustrative of the prior art.

Mr. Scott: I would like to inform the court that I wish to present this witness, and that after that we have in the Grand Jury room a mo lel machine which we would invite the court to see operate.

The Court: I might have said I do not see why these experiments should not have been made in the plant here at home. I don't see why you should invite the plaintiff to run outside of the jurisdiction of this court to see these experiments. I say you are entitled to introduce them under the plaintiff's authorities, regardless of what some of the Federal authorities say—entitled to introduce them, whether they have seen them or not. It goes to the weight and to the credibility; at the same time I do not see why these experiments should not have been conducted in the plant here. The court might want to see them, and of course the court is not going out of the jurisdiction.

Mr. Scott: It was a matter of convenience as to which plant could most handily do it. The plant which we refer to is a model plant, installed on the upper floor, and we would like the court to see that.

The Court: Of course the court is not saying that you have put in
your last experiment, but is simply suggesting, strongly, that
3825 you have used pretty nearly what the court would consider a
reasonable time. The objection will be overruled and an exception will be noted.

Q. 28. Do you remember, Mr. Janney, the point that you had reached; we were discussing the construction of the plant, and you had stated that it was your No. 1 retreatment plant, consisting of 2 emulsifiers and 13 frothing cells. Will you complete your description of the plant in which you conducted this operation with 323.73 lbs. of oil?

A. In my earlier testimony I described that we had two emulsifiers and 13 frothing cells in series. All of the concentrate from these 13 cells was sent directly to the concentrate bins, and the tail-

ing was sent directly to waste, and there was no circulation, as in the operations previously testified to.

Q. 29. Now, before you begin this test, as I remember, you stated this morning that you took some precaution to prevent any oil or any great amount of oil additional to that directly added being present?

A. Before I left Butte I telegraphed to Salt Lake, or to Garfield, rather, to have the circulation discontinued.

Q. 30. By circulation you mean the return of the middlings?

A. The return of the middlings.

Q. 31. And in the regular operation of this machine, just state where those middlings did go back to.

3826 A. In the regular operation of this plant the middling was returned to two elevators, and the pulp is there elevated to two four-spigot classifiers.

Q. 32. Those marked "Janney Classifier" at the left hand of the sheet, isn't it?

A. Yes.

Q. 33. Elevated to the classifiers. What are those classifiers for, primarily?

A. I might state that, in addition to the middlings going to the elevators, the original concentrate that is from the vanners in the mill also discharges into the same elevator, and with the middlings it is elevated to these two classifiers.

Q. 34. When you speak of the material from the mill, you mean the tailings from the gravity treatment in the mill?

A. No, it is the concentrate from the vanner, and part of that feed is what constitutes the feed to the flotation plant. These classifiers are used for the purpose of removing the coarse material, and this coarse material is treated by the Wilfley tables.

Q. 35. That is indicated on the drawing by the placard "Spigot to Wilfley Table"?

A. Yes, and the overflow from these classifiers is delivered to two Dorr thickeners, 44x12 feet, designated as Dorr tanks on the print. In my previous testimony I stated that these tanks were 44x20; I find they are 44x12. The overflow from these Dorr thick-

3827 eners is wasted, that is, it is not used any more, and the thickened product is divided between two plants, and inasmuch as I am only dealing with one plant in this experiment, I will refer to that plant only.

Q. 36. The two plants are indicated there by No. 1 plant, 13 cells in series, and lower down, No. 2 plant, 15 cells?

A. Yes.

Q. 37. And you are going to confine yourself to No. 1?

A. To No. 1, yes. Now, as the thickened product from the Dorr tank enters No. 1 plant, enters the emulsifiers, oil is added.

Q. 38. That is the place where it is so marked, "Oil Added"?

A. Yes, and our alkaline reagent is also added at the same place. The pulp, oil and reagent pass through the two emulsifiers, and thence to the flotation cells.

Q. 39. Now, Mr. Janney, I see as this sheet is made now, that you

have a placard here, "Concentrate from Upper Cells to Concentrate Bin; Number Left to Judgment of Operator." And below that there are several other cells, the froth from which goes back as middlings to the elevator. What is the effect of bringing back those middlings upon the oil supply?

A. It increases the oil supply.

Q. 40. Now, you had just got to the point of stating, I think, that you had the circulation cut out. You telegraphed to have the circulation cut out before you went to Salt Lake. Will you
3828 please state what the effect of cutting that circulation out was upon this oil supply?

A. Well, my object in having the circulation cut out was that in this test I would be dealing, as nearly as possible, with a pulp that had no other material in it except the feed that came from the classifiers. But the time allowed was not sufficient to allow all of the oil that was contained in these tanks to work out of the system.

Q. 41. In the Dorr tanks, you refer to?

A. Yes.

Q. 42. That is, some of the old material kept the oil in there?

A. Yes.

Q. 43. How long was this running without circulation before you started this test?

A. About 30 hours I believe it was. I believe I mentioned 24 hours, but that was just a rough figure. It was 30 hours.

Q. 44. Now, how much oil per ton of ore was there in the feed during this test, before you added the oil which you did add for the purpose of the test?

A. 1.04 pounds per ton.

Q. 45. That amount was in there by virtue of the residue in the Dorr tank?

A. Yes.

Q. 46. Would that 1.04 pounds per ton cause the formation of a froth concentrate?

3829 Mr. Garrison: That is objected to as speculative.

(Question withdrawn.)

Q. 47. Did you ever use the same mixture in amount as low as one pound per ton?

A. The lowest we used was in a test that I testified to earlier in the case, in which I used 1.6 lbs. of original oil, and I think there were four and a fraction pounds there already, so that the total was 6.68 pounds, if I remember correctly, and the results were negative.

Q. 48. By negative what do you mean?

A. They were not good results.

Q. 49. Did you ever run without oil at all—that is, without new oil added?

A. Yes.

Q. 50. What was the result then?

A. I noticed a few stray bubbles on the first spitz, that was all.

Q. 51. What were the conditions then as to residue of oil in the

Dorr tanks as compared with the condition when you conducted this test with 323 odd pounds of oil?

A. I believe there was in the neighborhood of four pounds per ton of oil.

Q. 52. And that gave only a few stray bubbles?

A. Yes—Well, I did not run that test with that oil amount; that was 1.6 pounds of new oil added to that, and I did get some froth on that test. I have not run a test where I used just the four
3830 pounds of oil in the circulation alone.

Q. 53. You have not made a test just with the oil that was left there from the circulation?

A. Well, not knowing the quantity of oil I haven't; I have run the machine, but I don't know how much oil was in the circulation.

Q. 54. Have you a statement containing a report of the operations of these gentlemen who are here and who worked under you in conducting this test?

A. Yes.

Q. 55. Will you produce copies of it or have I got them?

A. You have them.

Mr. Scott: I offer this statement in evidence, entitled "Utah Copper Company, Arthur Plant, Metallurgical Department, Eight Hour Test made in Retreatment Plant, etc."

Table marked Defendant's Exhibit No. 220.

Q. 56. What was done with the products, the concentrates and tailings before the assays were made; were they simply assayed as they came from the machine ordinarily?

A. All samples were taken in duplicate, one sample was taken for the purpose of determining the amount of oil in the product, and the other sample was taken for the purpose of determining the amount of metal in the products, and the samples taken for
3831 the oil analysis were taken by means of a cutter, having a one-half inch opening. These samples were taken every 15 minutes throughout the test, and the composite sample was allowed to accumulate during the test. The buckets containing the oil sample were delivered to our laboratory and turned over to Mr. Clauson who made the oil analysis. Like samples were taken for metal analysis, only the samples, after being collected, were delivered to Mr. Mieding, who has charge of our sampling, and he saw that the samples were properly dried, crushed, rolled and delivered to Mr. Martin, our chief chemist, at the assay office, who personally made the analyses.

Q. 57. Now, at the bottom of this sheet, which is exhibit No. 220, I find a note as follows——

Mr. Williams: I wanted to read this paper before expressing any objection, and having done so, I find upon it evidence that the operations could not by any possibility be a reproduction of any of the patents that are relied upon by the defendant. The mixtures are fuel oil, Jones oil, American creosote and Yaryan pine oil. Pine

oil was never used in flotation until years and years after our patent was granted; none of these other oils are the oils mentioned. There is an alkaline reagent here, 6.37 lbs. per ton, and I don't even know what it is, but judging by that plan, it is Calura, a recent invention in the art. The document shows upon its face that it is not an operation of the prior art, therefore *or* object to its reception in evidence and any testimony in regard to it.

3832 Mr. Scott: In the prior art patents, noticeably the Everson patent, she mentioned animal and vegetable oils generally, but never published all the different kinds of oils that might be used; it was impossible to name them all; Everson named various reagents to be added to the pulp, in her patent, and furthermore the argument advanced by Mr. Williams has no bearing upon the point at all. The process of Everson would be here none the less, or any of these other prior art inventions, notwithstanding that other things are here also. We have followed the Everson directions as set forth in the patent. She advises the use of a long list of different reagents, both acids and salts of every conceivable nature, and she names some of the salts she has used. She does not name them all; she names probably six or eight or ten. She speaks of the use of salts, and strangely enough, it is found in modern practice that the use of such salts is beneficial. She speaks there of the use of copper sulphate, which has been used since by the Butte & Superior.

The Court: It is in line with all the former testimony, and the court will adhere to its ruling. Perhaps this special objection was not made heretofore, but of course it will be a matter for argument later on. I think one witness testified to having a thousand different oils in his laboratory. Many of the results obtained today are traceable, according to the evidence, to new mixtures and combinations of oil. Whether that is part of the prior art is another thing.

3833 The question whether these oils are differently combined—and thus have different effects—I think they must, or they would not take so much trouble to mix them. At this time the objection will be overruled.

Plaintiff excepted.

Q. 58. I note at the bottom of your report, exhibit 220, the following note is made: "On account of products containing so much oil, they were washed with an oil solvent before the metal assays were made." Explain why that was done.

A. In this particular test, during the eight hours about 14½ tons of oil were used, and only 91.3 tons of material were treated. It was necessary that this oil should be washed out from the product in order to get a true metal assay of the product, and it was for that reason that I washed them.

Q. 59. Does this table show the amount of oil in the concentrate?

A. Yes, it is on the last column at the right of the sheet, on the fifth line down under the tabulation; 680.175 lbs.

Q. 60. There was 680 pounds of oil on the concentrates by assay?

A. Yes.

Q. 61. And is your pounds by weight of the concentrate increased by that 680 pounds of oil on them?

A. That 680 is not the oil contained in a ton of material rejected at the tailings, but it is the number of pounds of oil that would be carried out with every ton of concentrate produced.

3834 Q. 62. In every ton?

A. Yes.

Q. 63. Then you started with 91 tons of heads—of course that was without any oil at all?

A. Yes, that had one pound that came from the Dorr tank.

Q. 64. And would your results have checked up if you had figured your original tonnage as 91 tons, without this added oil, and then figured your concentrates with 680 pounds per ton of oil added to it?

A. I don't think I quite understand your question.

Q. 65. Well, your operation would have ended with more material than you began with if you had not taken the oil out, wouldn't it?

A. It would have ended with the amount of oil—with an amount of material equivalent to the amount of oil that I added to the machine.

Q. 66. Would another way of correcting that have been to have added the weight of the oil to the heading?

A. That would have been one way of correcting it, yes.

Q. 67. Instead of that, you washed the oil out of the concentrate?

A. Yes. I also washed the oil out of the tailings and heading.

Q. 68. Now, why is it that the combined amount of oil in the concentrate and tailing does not equal the amount of oil that you added?

A. That is due to the discrepancy in the oil analysis. On account of the concentrate containing so much oil I found it a difficult

3835 matter to dry off all of the water without carrying some of the oil with it. In this particular case I think it took over 24 hours to dry off the water before we could take a sample to determine the oil in it.

Q. 69. What kind of mixture was this froth after it was broken down and was being dried?

A. This concentrate mixture consisted, after it was put on the steam bath and the bubbles broken down, of a layer of oil floating on top of the water, and as the steam would be generated underneath the oil, it would bubble up through, and I am of the opinion that when this steam would rush through it would mechanically carry some of the oil with it. Also, on account of the oil standing in the presence of the air so long, I think some of the lighter oils volatilized.

Q. 70. Then the amount of oil, I see by these assays, adds up less than the amount that you actually added?

A. They do.

Q. 71. And therefore the figures here given of the amount of oil on the concentrates and tailings would that be less or more than the amount actually present?

A. What do you mean, actually present; the amount added?

Q. 72. Yes.

A. It would be less than the amount added.

Q. 73. What would be the total pounds of oil used per ton, based upon the amount of oil in the product?

3836 A. A little over 217 lbs. per ton.

Q. 74. That is based on the oil assay figures?

A. Yes; based on the amount of oil in the concentrates and in the tailings, and the amount of oil was 217 pounds.

Q. 75. As against the fact that you actually did have 323.78 pounds?

A. Yes.

Q. 76. How much of that oil can you account for by the oil assays of the concentrate and tailings, as compared to the amount of oil added?

A. Approximately 68%.

Q. 77. Have you told everything that you personally did in connection with those tests—with this test so far?

A. No, I have not. I gave instructions as to how this test should be run, that is, relative to what should be considered concentrates, how much oil I wanted used, and after those instructions were given I watched the operators in charge, to check the tonnage samples and the amount of oil added, and I would go there about every half hour and see that conditions were the same.

Cross-examination.

By Mr. Williams:

X Q. 78. How much of that oil was left in the plant at the conclusion of the operation?

A. We started the test at 5:45 p. m. April 29th, and we considered the test stopped at 1:45 a. m. of April 30th, and we discontinued sampling, I believe it was 30 minutes after we considered the

3837 test ended. That is, I had made determinations on that plant, and I found that it takes about 30 minutes for the feed to travel through the machine.

X Q. 79. I was wondering how much of that oil was left sticking to the spitzkasten and other parts of the appliances. You have lost something like 32% of the oil. Don't you think that you lost some of it by reason of the fact that it did not come out of the plant?

A. I did not look into the machine to determine that. It would be quite a job to do that.

X Q. 80. You don't know but what you left the plant in a pretty dirty condition as to oil?

A. Well, I can't say. What I could see was all right.

X Q. 81. I don't find in your statement any separate determinations as to the overflows from the 13 different spitzkastens; did you make them?

A. All we would know would be the total amount that the whole 13 spitzkastens were giving forth; is that right?

A. Yes, that is correct.

X Q. 82. Now, you ran the plant for 30 hours without circulation, but in the regular operations before the experiment?

A. That was before the experiment was started.

X Q. 83. You cut off the circulation but you did not stop the plant?
A. That is correct.
3838 X Q. 84. What sort of operations did you carry on in the plant in that 30-hour period?
A. Well, regular operations, using approximately 21 pounds of oil per ton.
X Q. 85. Using what kind of oil?
A. The same mixture which was stated in the table.
X Q. 86. So that you did not stop the machine at any time; you did not stop the plant; you just started to put in this extra oil?
A. Yes, the extra oil was started then.
X Q. 87. Now, you said that a determination was made of 1.4 pounds per ton of oil still in the feed before the point of oil addition. What kind of oil was that; do you know?
A. We do not make a determination to determine that. I don't know what kind of oil it was.
X Q. 88. Probably it was dissolved oil, wasn't it?
A. I can't say as to that.
X Q. 89. Won't your examination show that?
A. No, our oil determination does not differentiate between the kinds of oil contained in the feed.
X Q. 90. Well, your creosote had phenol in it. Would that be counted as an oil in your determination?
A. Well, to the best of my knowledge I think it is.
X Q. 91. It is in the oil when you feed it in?
A. Yes, sir.
X Q. 92. It goes in to solution and then as I understand it
3839 your method of determination catches it although it is in solution? That is right?
A. I think so, in small quantities like that.
X Q. 93. So that that determination includes whatever of phenol there was in that creosote that was fed to the plant?
A. I think so.
X Q. 94. Was all the oil fed in together at the point marked "oil added here" on your diagram?
A. Yes, all the oils were mixed together and were delivered to this point as indicated on the print by means of a little centrifugal pump.
X Q. 95. Did you heat the oils in mixing them?
A. Yes, they were heated when they were mixed.
X Q. 96. So they went into the plant in a heated condition.
A. Yes, they were warm. They were not—well, they were heated, yes.
X Q. 97. And of course the water at this season of the year is very cold, isn't it?
A. I don't know what the temperature of the water would be.
X Q. 98. You would expect it to be quite cold, wouldn't you, in your plant?
A. The atmospheric temperature on that day was I believe in the neighborhood of seventy degrees F.
X Q. 99. You don't have your water at atmospheric temperature, do you, in your plant?

A. Can't expect to, no. That is the only way I can tell you what the temperature of the water was.

3840 X Q. 100. You didn't take the temperature of the water?

A. No, sir.

X Q. 101. You didn't take the temperature of the oil as it was fed in?

A. No, sir, the oil was added at the same temperature as it is always added during our operations, same kind of oil, heated to the same degree. We have a vat with a steam coil running through it and that steam coil is allowed to be on all the time. We have to heat all of our oils, no matter what kind they are. Even our creosote oils have to be heated. In them there are certain constituents that otherwise would precipitate out.

X Q. 102. You did not give us the actual discrepancy in your figures between the oil that you put in and the oil that you got out, but I compute it as 9,388 pounds. That is a tremendous amount of oil, isn't it, to lose in an operation of a few hours.

A. Well, not considering the amount of oil used, 30 per cent I believe is what it figures—32 per cent.

X Q. 103. Don't you agree with me that you will find people at work now to get the oil out of that plant?

A. No, our operations went right on the same; we didn't notice any difference after we discontinued this test.

X Q. 104. Now, how about the oil that went into this dilution, that is the soluble frothing agent that was present there? Did you figure carefully all of that?

3841 A. I am not a chemist, Mr. Williams, and I am not in the position to state.

X Q. 105. Well, when you took your samples?

A. Oh, yes, absolutely.

X Q. 106. You took all the water that was there?

A. Every bit of that was taken.

X Q. 107. Now, Mr. Janney, when you were on the stand before you promised to get a flow sheet of the plant and I take it that this flow sheet that you have put in is a complete flow sheet of the vanner concentration flotation plant, is that right?

A. Yes, sir. And while you speak of it there was one correction I wish to make before I forget about it. You asked me while I was on the stand before how we determined the amount of oil in our circulating feed and I said that our circulating feed was determined by tonnage samples and a representative sample was taken to the laboratory and an analysis made of it. I believe that is what I conveyed to you. But as a matter of fact, that tonnage sample is taken at the point I have indicated on this print as such, and that sample is determined by analyzing the feed for a number of tests before it goes into the emulsifier and the amount of oil found in that feed is credited to the tonnage of circulating feed. We do that for the reason that some of our oils might flow off from the Dorr tank and not go back to the flotation machines.

X Q. 108. Of course there is an overflow from all of these Dorr tanks all the time that goes to waste?

3842 A. Yes, sir, that is the reason why we determine our oil in the circulating feed at a point after it is discharged from the Dorr tank and before entering the flotation machine.

X Q. 109. And it would be a very reasonable thing for any loose oil to rise to the top of the tank and overflow, wouldn't it?

A. Yes, sir, but I have noticed it on several occasions. As a matter of fact in my inspection, that is one of the things I noticed very closely, to see if any oil was going off the tank, and I don't know that I have ever noticed any perceptible amount of oil going over with the overflow. But in case there was any going over in the overflow, we don't credit that to our circulating feed.

X Q. 110. I understood you had a table in which you had added certain things that I asked for. Have you got such a table?

A. I think Mr. Scott has that.

Mr. Scott: Maybe it would simplify matters if I would substitute this exhibit instead of having the two in. It is just the same but with the added column.

Mr. Williams: I think so far as the record is concerned if it appears in the record that it is stipulated that the other be withdrawn and this substituted in its place, that would be all right.

Mr. Scott: Well, then let the record show that it is stipulated that exhibit 30 be withdrawn and the paper which I now offer be admitted in its place and marked Defendant's exhibit 30, subject to comparison by opposing counsel.

3843 The Witness: I have not personally checked these figures. There may be typographical errors in it, but I will have it done and if there are any errors I will notify you.

The sheet in question was marked "Substitute exhibit 30, admitted."

X Q. 111. What is this alkaline reagent which appears on exhibit 220?

A. That is the same reagent we use in our general operation. I believe I described it in my earlier testimony.

X Q. 112. Calura?

A. That is the name we give it.

X Q. 113. That originated in your plant, did it not?

A. It did.

X Q. 114. Do you know who invented it?

A. Mr. R. B. Martin.

X Q. 115. And it was invented, we will say, within the last five years some time?

A. As far as I know it was.

X Q. 116. It doesn't appear in Nature, that calura?

A. No, we make it right at the plant.

X Q. 117. Now, you haven't any of the baskets or Callow cells shown in your flow sheet. Do you use any in your plant?

A. Not in this plant we don't. It is a straight mechanical machine.

X Q. 118. And no pneumatic attachment in any way to any of the spitzkastens?

A. None whatever.

3844 X Q. 119. You testified about another plant, didn't you?

A. Our slime plant, yes.

X Q. 120. Have you given me a flow sheet of that?

A. I think Mr. Scott has that.

Mr. Scott: I will offer this flow sheet produced by the witness, the same being entitled flow sheet for slime flotation plant, Utah Copper Company, Arthur plant.

Flow sheet admitted in evidence and marked Defendant's Exhibit 221.

Mr. Scott: Suppose you describe this drawing briefly?

A. Do you want me to go into detail?

X Q. 121. Tell us what it shows?

A. It is self-explanatory. That feed that comes to our flotation plant is the slime that is produced in grinding the original ore and consists of our classifier overflow. That is delivered to one 75 by 12 feet Dorr thickener. The overflow is returned to circulating—that is, returned back to our reservoir and the thickened feed goes to the flotation plant, consisting of six independent flotation units, each unit being composed of two emulsifiers in series, followed by five mechanical air cells in series, making a total of 12 emulsifiers in the plant and 30 mechanical air cells. The feed, after coming from the Dorr tank is divided by means of a distributor pipe to each of these six independent units. Oil is added before the pulp enters the units. The tailings from the last cell of each unit is dis-

3845 charged or rejected. The concentrate made in these three cells is pumped to an equalizing tank or a small tank which takes up the pulsation in the pulp, and this product is distributed to five independent units consisting of two mechanical air cells in series, making a total of ten cells in the whole plant. That is the cleaner plant as this plant is called. The tailings from this plant is returned to the 75 by 12 foot Dorr thickener and the concentrate goes to our bins and to Portland filter.

X Q. 122. As finished concentrate?

A. Yes, sir.

X Q. 123. Now, in your drawing of the upper part or rougher plant, you draw the emulsifiers just the same as you draw the mechanical air cells?

A. This is just a diagrammatic representation of the plant.

X Q. 124. As a matter of fact the emulsifiers have no spitzkasten, and the air cells have spitzkastens. That is right?

A. Yes, sir.

X Q. 125. Are these mechanical cells of the double spitzkasten variety or the single spitzkasten variety?

A. This is a mechanical air, as we call it, it is a double spitzkasten variety.

X Q. 126. That is to say, each one of these cells consists of a separate agitation chamber, a spitzkasten at one side and another spitzkasten at the other side and then on each of these spitzkastens there is a sort of false bottom, with a canvas bottom, and
3846 compressed air is forced in, is that right?

A. Yes, practically.

X Q. 127 And that runs on all through the plant?

A. Yes, sir.

X Q. 128. Everything there is mechanical air?

A. Yes, sir.

X Q. 129. Now, in your experiments in the slime flotation plant as stated in your table exhibit 32, you have a series of numbered experiments and you have not identified them by the dates and durations of the experiments, although I had you do that as to the others. Will you supply that information now?

A. I haven't the data right here at present.

X Q. 130. Please obtain the data and let me have it.

A. The duration is given on there.

X Q. 131. The duration is given but not the succession?

A. That is the time of the test?

X Q. 132. The data as to the shifts, if you have that, because they are nearly all one shift and some of them half shift operations?

A. I will do that.

X Q. 133. And then there was a little doubt in your mind as to what shift some one of the experiments in the vanner concentrate plant occurred in. If you can supply that also, please do so?

A. Yes, sir.

3847 Redirect examination.

By Mr. Scott:

R. Q. 134. How much oil per ton was found on the tailings as shown by this exhibit 220, your report?

A. 20.73 pounds per ton of tailings rejected.

R. Q. 135. Did you observe the appearance of the float formed during this run with 323.78 pounds of oil?

A. I did.

R. Q. 136. Will you describe it and compare it with the float upon other occasions?

A. The froth produced was composed of a mass of air bubbles, minerals, some slime and oil. Had every appearance of a froth produced in our plant with the exception that it was considerably more oily. The oil was very apparent.

Recross-examination.

By Mr. Williams:

R. X Q. 137. What you said applies to the bulk of the concentrates as a whole?

A. No, it was that way throughout the whole plant.

R. X Q. 138. It looked all alike in every one of the 13 spitzkastens?
A. No, there was more on the upper cells.
R. X Q. 139. The first cell overflowed a tremendous amount of oil, didn't it?
3848 A. The first five cells seemed to be about the same.
R. X Q. 140. Overflowing great amounts of oil?
A. Yes, sir.
R. X Q. 141. And then as you went down the line the oil condition diminished?
A. Yes, sir.

Re-redirect examination.

By Mr. Scott:

R. Q. 142. Was that oil that was overflowing separating from the rest of the pulp, or forming a part of the froth?
A. No, it was all air bubbles.

(Witness excused.)

Mr. Scott: Mr. Sutherland will be the next witness.
Mr. Garrison: If your honor will take the customary recess I think we can save a lot of time. We are not going to require these people to produce all of these assays. We usually take a recess about this time and it will be a very useful one now.

(Whereupon a short recess was taken.)

Mr. Garrison: We will admit without the necessity of proof that the statements appearing on exhibit 220 correctly represents the result of the assays, weighing and so forth, which they purport to represent. Is that satisfactory, Mr. Scott?
Mr. Scott: I think so.

3849 David Douglas Punchon, called as a witness in behalf of the defendant, being first duly sworn, testified as follows:

Direct examination.

By Mr. Scott:

Q. 1. State your full name.
A. David Douglas Punchon.
Q. 2. What is your occupation?
A. Flotation foreman, Arthur plant, Garfield, Utah.
Q. 3. It is your duty I presume to superintend the operations of the flotation machines of your company?
A. Yes, sir.
Q. 4. Do you operate both the machines which treat the slimes and also the ones which treat the concentrates and if not, which one?
A. I operate both of them. sir.
Q. 5. Have you ever operated——
A. That is, in saying "operate" I superintend all the operators,

that is during my shift, I don't operate them personally but I see that they are operated.

Q. 6. Have you ever operated these machines with an oil composed of a mixture of 59 per cent fuel oil, 20 per cent Jones oil, 10 per cent American creosote No. 2, and one per cent Yaryan pine oil?

A. I have, yes, sir.

Q. 7. In the regular operation of the plant?

3850 A. Yes, sir.

Q. 8. And when so operating the plant and with that oil have you ever turned the oil supply completely off?

A. What machine do you refer to, the retreating plant?

Q. 9. Yes, sir.

A. Yes, sir.

Q. 10. I mean the one that retreats the concentrates.

A. Yes, sir.

Q. 11. You have turned off from the one that retreats the concentrates?

A. Yes, sir.

Q. 12. And what happens?

Mr. Garrison: This goes in under our general objection without the necessity of repeating it.

The Court: Yes. What is the object of this?

Mr. Scott: It is to connect up with that 1.04 pounds of oil which was left in during this test and to show what effect it would have.

The Court: This is all subject to the general objection. Of course it is a standing objection.

Mr. Scott: What was the effect when you turned it off?

A. It would hold the cell in suspension—hold the mineral bound in the cell in suspension.

Q. 13. And just explain what you mean by that. I don't understand it?

A. That is it will hold the froth up.

Q. 14. Hold it up, you mean just suspend it?

3851 A. Suspend it, yes, sir.

Q. 15. Or stop it or what?

A. Just suspend it there. It will lose its action after a very short time. It won't displace for a moment but what it will lose its time there.

Q. 16. After a minute has passed, following the complete shutting off of the oil supply, state whether there will be froth or won't be froth in the spitzkasten?

A. It will gradually die away entirely in the spitzkasten, and cease to have any selective action whatever.

Q. 17. And how long before it dies away?

A. Well, sir, I wouldn't give it accurately, practically—the effect will take perhaps from a minute to five minutes you won't have no froth there.

Mr. Scott: That is all.

Cross-examination.

By Mr. Williams:

X Q. 18. When did you test this?
A. We have tried this several times in using our judgment on the oils.
X Q. 19. And was that under conditions where the circulating load was going around?
A. Yes, sir.
X Q. 20. That was done under your present operations, using something over twenty pounds of oil to the ton of ore?
A. Yes, sir.

Mr. Williams: That is all.

(Witness excused.)

3852 REX SUTHERLAND, called as a witness in behalf of the defendant, being first duly sworn, testified as follows:

Direct examination.

By Mr. Scott:

Q. 1. Please state your full name?
A. Rex Sutherland.
Q. 2. What is your position?
A. Flotation foreman.
Q. 3. Flotation foreman?
A. General flotation foreman.
Q. 4. Over all three shifts?
A. Yes, sir.
Q. 5. Where?
A. Arthur plant.
Q. 6. Mr. Sutherland, Mr. Punchon that just testified is foreman of one shift, isn't he?
A. Yes, sir.
Q. 7. And you are the foreman of the entire three shifts?
A. Yes, sir.
Q. 8. In operating the Arthur flotation plant, have you ever cut off the oil supply when using a mixture composed of 59 per cent fuel oil, 30 per cent Jones oil, 10 per cent American creosote No. 2, and one per cent Yaryan pine oil?
A. Yes, sir.
Q. 9. And what happened when you shut the oil supply completely off?
3853 A. Why, your froth, you will have your froth just the same for possibly, I should say thirty seconds before you can notice it, in just the ordinary course of operations. Sometimes the elevator will stop and you won't have any oil going in there. Well, the operator will stand and watch that and he will immediately notice his froth die, won't have any agitation in the back

and within—if he lets that go, within say three minutes there won't be any froth in the first cell at all.

Q. 10. The first, that is the head cell?

A. Yes.

Q. 11. And how about it down through the line?

A. Well, it takes longer to work down through there, goes right on down through the line.

Q. 12. How long before that condition spreads through the machine?

A. Well, I should say it would take ten minutes to go all through the machine before the froth would entirely disappear.

Q. 13. Well, do these statements that you are making apply to the slime flotation treatment or to the machines that are treating the concentrates?

A. The machines that are treating the concentrates.

Q. 14. The vanner concentrates?

A. Yes, sir.

3854 Cross-examination.

By Mr. Williams:

X Q. 15. How recently have you made that sort of a test?

A. Well, we made them as they occur, several times, just in the ordinary course of operations.

X Q. 16. And during that period in which you have been using more than twenty pounds of oil to the ton of ore?

A. Yes, sir.

X Q. 17. You spoke of it as a result of the elevator breaking down. I don't quite understand it. Just explain it.

A. Well, something would break in the elevator, something like that.

X Q. 18. What does the elevator do, the one that breaks under those conditions?

A. Well, that sends the oil into the machine.

X Q. 19. Sends the ore?

A. The oil.

X Q. 20. Oh, you have an elevator for oil?

A. Yes, sir.

X Q. 21. And you were talking of the oil elevator?

A. Yes, sir.

X Q. 22. And everything else in the plant will be running, middlings returning and so on, they will all be running the same, and when you stop the oil supply what you speak of happens, is that right?

A. Yes, sir.

3855 Redirect examination.

By Mr. Scott:

R. Q. 23. Were middlings being returned? Did you have a circulating feed at that time, the time the oil was completely off that you testified about?

A. Yes, sir, during the regular course of operations, we have the middlings returned.

Witness excused.

Dr. SAMUEL P. SADTLER, recalled, testified as follows:

Direct examination.

By Mr. Scott:

Q. 593. Dr. Sadtler, you have heard, have you, the description of these operations at the Arthur plant that Mr. Janney testified about with 323.78 pounds of oil per ton of ore?

A. I heard Mr. Janney's testimony.

Q. 594. Will you compare that operation with the disclosure in each of the following: The Everson patent, the California Journal of Technology, the Kirby patent and Froment, as to the following: I would like a comparison made as to the powdering of the ore, its admixture with water, the addition of oil and agitation?

A. The first in order of these disclosures of course is the Everson patent. In the Everson patent we have covered first of all
3856 on page 1 of the Everson patent as part of the Everson invention: "A fat or an oil, either animal, mineral or vegetable." That is broad enough to cover any admixture of oils or fatty oils, essential oils or any constituent or derivative from paraffin, or any mineral oil, irrespective of the question as to whether the essential oil may be in part soluble or not, or whether it may be totally insoluble. We have then the presence of acid, either mineral or vegetable acid used. Now, passing to the process indicated in the Everson patent, we have the second and third steps, as I termed them before, the first step being that operation wherein the acid and the oil were mixed and allowed to stand together for a time before adding that mixture to the oil. I leave that to one side and turn to the second step of the Everson patent in the use of petroleum or a liquid constituent thereof, like paraffin oil, and then the third illustration of the Everson patent. It is stated clearly: "It is also not essential to my invention that the acid or salt employed with a vegetable oil be added to the oil before the incorporation of the oil with the ore, as it is entirely practicable, at least in most, and possibly in all, cases, to first mix such oil with the ore and thereafter add the acid, as set forth in the use of petroleum." That makes the method which was described more fully in connection with the use of petroleum available and extended to the use of any of these types of vegetable or animal oils, but at all events to vegetable oils, and that of course includes the fixed oil or fatty oil preparation and the essential
3857 oil. So that Everson contemplates the operation as described more fully under petroleum as applying there also.

Now, we have in the Everson patent the pulverization of the ore, finely powdered, "the reduction of the quartz or other rock containing the mineral to a powder," reducing the mineral to a comminuted state as described on the first page, and then we have in this second

or third process the mixing of the finely powdered or comminuted ore with the oil. Everson gives an example in which 17 per cent was used. That is an example and is not binding, but well known, as I indicated.

Then we have next in the practice the concentration, after thorough agitation of the mass. That is the agitation step, which is applied in a small way or applied in a large way, and was the agitation step of the Utah practice. And the detachment of the sand, which means the separation of the gangue, and next: "Will in this case be preferably removed by means of a constant overflow of water from a washing-out vessel, by which overflow the concentrate will be floated off."

That represents the steps of the process, what takes place on the spitzkasten, and represents the passing off of the froth or of the mineralized ore froth. The amount which was used, as I understood Mr. Janney to say, was 323 and a fraction pounds per ton. That is very close to 16 per cent, 16 per cent of oil or oil mixture practically was used in that case. That is very close to the 17 per cent of Everson and practically is in the same class of operation with the
3858 amount of oil.

Passing next to the Kirby patent, we have in the Kirby patent, coming as late as—his application of December 14, 1903—we have in the Kirby patent the finely pulverized ore or mineral matter, enough water to make with the same a floating pulp and then either kerosene or "a solution of bitumen in a thin distillable hydrocarbon liquid, as kerosene" and these mixed so thoroughly, agitated together so thoroughly "as to finally subdivide said solution into small globules and bring said globules into contact with substantially all of the pulverized mineral particles which will, by preference, adhere to them." And, following that: "In allowing the hydrocarbon-coated particles to float to the surface of the mass." Now, that first step of the Kirby process is the exact counterpart in principle, as I will point out in a minute in some details, with the large scale process which was carried out and described by Mr. Janney. In the first place, in this Kirby process we have an efficient agitator—agitation shown and with rapid agitation, "Violent agitation" in fact the claims say, in the first or mixing vessel. That is the type of the mixing mechanism which was used in the experiment described by Mr. Janney. At the time of this Kirby application there were mechanisms, as I testified before. There were other forms of efficient mixing apparatus known, distinctly two in number, the Johnson mixer and the Gabbett cone mixer. So that there was available a mixing apparatus exactly of the same mechan-
3859 ical type as that which was used in the large scale operation at the present time. All of the principles necessary to produce the froth were here indicated as the illustration of efficient agitation.

Turning to the Froment. In the Froment description and the Froment machine we have also a form of agitation which is quite efficient. That is the revolving oval, the oval forms of rotating blades which rotate in opposite directions and thereby create strong

or really thorough agitation and entrain air and produce a froth in the presence of the proper amount of oil with the floating pulp and the presence of mineral sulphide particles; this froth is stabilized so that we have the production of an efficient froth as a step shown in that Froment description and the Froment patent in the first of these vessels of the Froment patent, called the mixer in the Froment description, all of the principles are the same there, their production of a froth as in the practice in the large scale. The froth in the case of the Froment description is carried off into a second vessel and there is supplemented by that acid treatment using some calcite, but that is cited as a secondary step and does not bear upon the main feature of the mechanism, and the application of the principles necessary to produce a froth.

In the case of the California Journal of Technology, we have no machinery. We have only the showing of an efficient froth, of getting the foam effect, as it is called; but in the getting of
3860 this foam effect we have the principle there of the flowing ore pulp and the small amount of oil, and that was smaller than was referred to in this other case, the 17 per cent of Everson, 25 per cent to 75 per cent of Kirby and the 16 and a fraction per cent as practiced in the Utah experiment. And then the violent agitation, and with these elements which are the same in all of these cases we get the mineralized froth of the California Journal of Technology when we used a modern—when we used a form of mechanical agitator which was however, abundantly known at the time of the California publication, that is, the Gabbett cone mixer, which was patented in 1889 already, which we used then in the experiment that still stands there for illustration of the California Journal of Technology proceedings, we got a fine froth, mineralized froth.

So that in all four of these publications stated, all belonging to the prior art, we have a clear statement of all the principles involved in the raising of a froth as practiced by Mr. Janney using 323 pounds of oil mixture to the ton of ore, approximately 16 per cent.

Cross-examination.

By Mr. Williams:

X Q. 595. Do you regard this operation by Mr. Janney as the carrying out of what you have discovered to be the three methods—to be the third method of the Everson patent?

A. It would come under that clause rather than under
3861 the second because his mixture was largely—well, it would be a mixture of oils, oil—all of them covered clearly by Everson in her statement—covered clearly by Everson in her patent. That is as I understand her: He had some fuel oil, had some pine oil and that goes into the two classes of paraffin product and vegetable oil. But as the process described in Everson is equally applicable so stated by Everson, I seee no reason why we should not use a mixture.

Witness excused.

BEN H. DOSENBACH, recalled, testified as follows:

Direct examination.

By Mr. Scott:

Q. 1. In the Butte & Superior flotation plant is there any difference in the level in the pulp in the roughers and cleaners? Any difference in the point at which the froth is taken off?

A. Yes, there is a difference.

Q. 2. And what is the difference?

A. The level of the pulp in the rougher cells is carried much higher in the spitzkastens than it is in the cleaner. That is the lower portion of the froth is much higher in the spitzkasten in the cleaner than it is in the rougher cells.

Q. 3. And what is the reason of that?

3862 A. The object being to take off the froth to the cleaners only without any of the pulp, and the object in the rougher cells being to take off as much as possible but not so high a grade, in order to make the recovery.

Q. 4. I would like to have you look at the California Journal of Technology a minute and tell me what you understand by some of the terms. Now, under that tabulation of experiments which occurred after the heading "test—molybdenite ore" we find the first paragraph relating to tests 1, 2 and 3, then the next paragraph relating to tests 4, 5 and 6, and the statement is made: "This method gives the highest grade of concentrate of any of the direct treatment here outlined." The word, "direct" I wish to call your attention to that. Then, in the following paragraph: "But these concentrates were not marketable. In practice they would have to be reconcentrated" and the word "reconcentrated" and then one of the columns in the table above is headed "number of treatments." Now, I would like to know your understanding as a metallurgist of the significance of that term "number of treatments" at the head of that column, and of the word "reconcentrated" and the word "direct"?

Mr. Williams: I object to the testimony of this witness in explanation of the column headed "number of treatments" because he has not qualified, either by a study of the document as a whole or by knowledge of the meaning of terms in the days of this invention so as to enable him to testify as to what this means. So far as

3863 the meaning of the word "reconcentrate" and I think something else is concerned, I see no particular objection to that, but it seems to me the witness has not qualified to express an opinion on this matter.

Mr. Scott: Maybe I can qualify him.

Q. 5. Have you studied this article in the California Journal of Technology?

A. I have.

Q. 6. Have you performed operations that you considered to be in conformity with the directions contained in that article?

A. I have.

Q. 7. I think you qualified before as to your scientific education and experience, did you not?

A. I did.

Mr. Scott: I submit, your honor, that with the qualification of this witness he is in a position to impart information to the court and ourselves as to the meaning of technical terms.

The Court: Well, is there any difference between the way these terms were used in that day and this?

Mr. Scott: I know of no difference.

Mr. Williams: I don't believe the witness does. That is the difficulty.

Mr. Scott: Well, the test is as to his understanding of these words.

Mr. Williams: His knowledge commenced in 1906.

3864 Mr. Scott: Well, the article was written in 1903.

The Court: Well, the presumption runs forward a little I consider so now it may run backwards a little. I will allow him to answer. The objection will be overruled.

A. Experiments Nos. 4, 5 and 6 as stated in this article show the results obtained by treating separate samples with small quantities of oil and in a salt solution, agitated violently to produce the foam effect. Now, this article says this method gives the highest grade concentrate of any of the direct treatment here outlined. I would say that means that it is a comparison of the results obtained between the three experiments when a large quantity of oil was used and the three experiments when a small quantity of oil was used. Then further along in the experiment No. 6, 10 cc. of oil was used for 100 gms. of ore. It states the recovery as being 75 per cent and the concentrate 32.4 molybdenum sulphide. It also states that the concentrates were not marketable; in practice they would have to be reconcentrated. That means that the concentrate produced by the initial treatments were not of sufficient value to be marketable and would have to be retreated again in order to obtain a proper grade. Consequently the description of a retreatment of the concentrates follows in the next paragraph.

Q. 7½. Well, with this—would this reconcentration referred to here correspond to what you call "cleaning"?

3865 A. Yes, it would correspond to what we call cleaning.

Q. 8. Now you did not tell us your understanding of the head of that column, "Number of Treatments."

A. I was just going to. In the fifth column, under the head "Molybdenite," setting forth the various steps in the experiment that were performed, the heading of the fifth column is abbreviated but I take it to mean number of treatments. I should say that the number of treatments in this column means the number of times the process was carried out and the number of times the concentrate was removed, which corresponds directly to the operations in flotation, wherein a number of cells are used to constitute a flotation unit.

Q. 9. Do you remember, or did you make a record of the speed of

the revolutions of this Fryer Hill machine in which you made a demonstration in court the other day?

A. I think I stated the speed.

Q. 10. Do you remember it now; I don't remember whether you stated it or not.

A. From fourteen to fifteen hundred I think it was; I am not positive without looking over the record for that day.

Q. 11. In the Butte & Superior plant I think the witnesses have stated that sulphuric acid is used. Will you state where that is added to the pulp?

A. In practically all of the operations the acid is usually added to the feed before it enters the flotation plant; that is, there is
3866 a time which elapses between the time the acid is added to the feed going to the flotation plant and when the feed enters the flotation plant.

Q. 12. How much time do you suppose; a matter of minutes or hours?

A. Well, it might be minutes and it might be hours, all depending on the circuit. I should say it would be possibly fifteen or twenty minutes.

Cross-examination.

By Mr. Williams:

X Q. 13. In the California Journal of Technology as I understand it, the operations were carried on, as far as molybdenite ore was concerned, in percolating tubes, weren't they?

A. They were.

X Q. 14. Do you understand what the number of treatments means as applied to those experiments, that were clearly Elmore experiments, Nos. 1, 2 and 3?

A. I would take them to be the same as the other experiments following, 4, 5 and 6.

X Q. 15. They also were carried on in the Elmore p cess in these percolating tubes. Tell me what the procedure was.

A. The oil may have been taken off; I don't know the method.

X Q. 16. Start at the beginning.

A. Beginning on page 35 of this article it gives the conditions of the various experiments that follow, and it gives the labora-
3867 tory method for conducting the tests. There are two different ways of mixing which is stated on page 36. One is by agitation, thorough agitation, and the other is by very gentle agitation, the oil being kept in a single lake and broken up as little as possible consistent with a thorough contact of the pulp and oil, which describes the Elmore procedure, and the following describes the agitation and formation of a froth procedure which states that—It states that each method has its advantages and disadvantages. Now it says, directly following that: "The mineral laden oil was then skimmed off with an aluminum ladle." And it goes on to state why aluminum was used and the comparison between aluminum and glass, and I take that to be an accurate description of how the

mineral laden oil was removed. It says it was skimmed off with an aluminum ladle, and down below in this table that I was referring to, it says "Number of Treatments." So consequently I would take it that it was treated again.

X Q. 17. As you read it there it says "The mineral laden oil is then heated and treated in the centrifugal separator as above described." Does it not?

A. That is a correct reading of one of the paragraphs of this page, yes.

X Q. 18. And that immediately follows a repetition of that description of the methods of agitation, one by inverting the tube, two by rotating the tube, three by violently shaking the tube; and then the statement that the charge having been thoroughly mixed,
3868 the tailings were allowed to settle, the solution is added through the oil on top of the tube, the concentrate being floated off as shown in Figure 26. That is right, isn't it?

A. No, that paragraph describes three methods of mixing by agitation, because there is one which is inverting the tube several times, and another by rotating the tube and another by violently shaking, which is differentiated some from the first two.

X Q. 19. But that paragraph describes just three methods of mixing?

A. Yes.

X Q. 20. Then it proceeds to tell you what is done after the mixing, doesn't it?

A. Yes.

X Q. 21. And we find the mineral laden oil is heated and treated in a centrifugal separator. Isn't it reasonable to assume that the men who described these experiments told you what they did, and that when they say they do something, that they did do it, therefore, that they did it by those three methods?

A. No, I could not interpret it that way.

X Q. 22. Now, let us return to the table itself. The first, No. 1, we have 2400 grams of oil and 2000 grams of ore; that is the largest amount of oil of all of the experiments isn't it?

A. Yes.

X Q. 23. Now, we find there were four treatments; now you know that in the Elmore process that is just what they do, and that is what these men say they did; they take the concentrate, float
3869 it off; and treat it in a centrifugal separator, and separate the oil, and then they put the oil back again and see what more they can do with it; isn't that right?

A. In the Elmore, yes.

X Q. 24. And they have succeeded by that means in getting four different treatments; that is a reasonable interpretation of what it means, isn't it?

A. Yes.

X Q. 25. The next column we have 2000 grams of oil and 2000 grams of ore; that is a little less oil, and they only got three treatments. That would be treatments of the kind that they have spoken of here, would they not?

A. They would.

X Q. 26. The kind I have mentioned?

A. Yes.

X Q. 27. The last one of the Elmore, we have a thousand grams of ore and 1200 grams of oil, and there there are three treatments. That would be the same kind of retreatments I have described here, would they not?

A. They would.

X Q. 28. And now we go down to experiment No. 4, where there was 2.1% of oil, and there was only one treatment. That would indicate, would it not, that they were not able to get enough oil out of it to start over again?

A. No, I don't say that that would indicate that they could not get enough oil out of it, because the next one follows with two
3870 treatments, and the next one with three.

X Q. 29. And that second one had twice as much oil—more than twice as much?

A. Yes, it had.

X Q. 30. And the next one had almost three times as much oil, or a little more than three times as much oil, 8.9%, and there you get three treatments; now, isn't it reasonable to assume that since the number of treatments correspond with the amount of oil, that the students did the same thing with their smaller quantities of oil that they did with their larger quantities of oil?

A. I can not conceive how they could get the oil out of the concentrate on that experiment No. 4, wherein 2.1% of oil was used, and I agree with you that if there was not enough oil when they were using 2.1% to get it out, then they did not make any more treatments because the oil was not perceptible, possibly.

X Q. 31. Your theory as I understand it was, that they shook the ore and oil in a percolating tube and took off the concentrate, and then they shook it again in the percolating tube and took off the concentrate, and then they shook it again; is that your theory?

A. That is not specifically stated, that they did that; it might have been according to your theory of adding more oil, and it might have been that they shake it over and over again. It can be taken
3871 both ways in this. And even if it was with more oil, it shows the betterment of the recovery.

X Q. 32. A reasonable interpretation of that would be that in the 5.3% experiment where they had two treatments, that they agitated the tube, formed the froth, and then added the same kind of oil and agitated again and took off that froth; that would be the two treatments on your theory?

A. That is one way according to my theory; the other way is that they agitated once and took off the froth, and agitated again and took off the froth; that is one way that they might have carried out the operation, and the other way that they might have carried out the operation.

X Q. 33. As a matter of fact you are not certain what those students meant when they were writing this description of their labora-

tory operations with nothing before them except the Elmore process to guide them; that is true, isn't it?

A. Well, they had the Everson; they stated back here that they had the Everson to guide them in a way.

X Q. 34. You notice that they do not speak of the Everson as a frothing process, don't you?

A. They speak of the Everson as bringing forth the use of acid, and give her credit for the use of acid in the processes of separation. Then they themselves, I think, must be given a great deal of credit for froth flotation, because they mention the word froth, and they mention agitation, and float, and I can not see any other way but what they themselves must be given a great deal of credit
3872 for the production of a mineral froth.

X Q. 35. I am not discrediting the ingenuity of the students, but I am trying to make out whether you can be sure as to what they meant when they said the number of treatments, 1; number of treatments, 2; number of treatments, 3, in this printed document. You are not sure whether in their retreatments they added oil or whether they omitted to add oil, are you?

A. I am not sure about that; as I stated before, it can be taken both ways. If there was sufficient oil present that they could obtain from the concentrate to put back again into the next agitation procedure, then that operation could be carried on that way. If that was not possible, they did not do it that way.

X Q. 36. But you can not be certain which way they did it?

A. I give two statements as to what my interpretation of it is.

X Q. 37. And you don't know which one they did?

A. Which one of them, that may be correct.

X Q. 38. Now, you were to let me have a flow sheet of the Butte & Superior mill as it was operated in the presence of the plaintiff's representatives.

A. I have prepared a flow sheet for you, Mr. Williams, according to that.

X Q. 39. Suppose you describe it as briefly and clearly as you can.

A. The flow sheet as represented upon this tracing, is very similar to the one previously described by me in court, with the exceptions that there are several changes, which I will note. On Sun-
3873 day, April 29th, there were seven pyramid roughing cells in operation, which are numbers 1, 2, 3, 4, 5, 6 and 7. The number 8 pyramid machine was in operation as a cleaner unit, and was used to clean the concentrate from No. 1 cleaner, which is this cleaner that I am now referring to. Now, the four middling cells on one side of the pyramid machine, or on one side of the agitating cells were blocked off, so that none of the froth was taken off in those spitzkasten. That is what occurred for all of the pyramids with the exception of No. 5. No. 5 was open on both sides; it shows here to be closed, but I have just made several crosses here and notation, denoting that these four cells were open in this pyramid machine.

X Q. 40. When you say blocked off, you mean the entrance to them was closed so that no liquid could get into them?

A. The duct from the agitation cells to the spitzkasten was closed, so that there was no circulation or no pulp flowing through these four spitzkasten. That was the condition of the pyramids, as I have said, with the exception of No. 5 pyramid. Now, the flow through the plant was substantially as described before, with the exception that of the middling cells, which constitute four of the later pyramids——

X Q. 41. The last four?

A. The last four of the pyramid cells—it was only taken off on one side. This cleaner, which we will call No. 1 cleaner, was the first cleaner, and to it was brought the rougher concentrate produced by the first three cells of the pyramid machine. The con-
3874 centrate from No. 1 cleaner was pumped up to No. 2 cleaner, producing on the first three cells a second cleaner concentrate, which was elevated to No. 3 cleaner, which produced a final concentrate. The No. 3 cleaner produced a finished concentrate. The last four cells on one side of the second cleaner produced a lower grade concentrate, which went to the No. 1 cleaner, and again through the circuit up to No. 2 cleaner. The tailing from No. 1 cleaner went back as a middling. The tailing from No. 2 cleaner went out to waste as a discarded product. The tailing from No. 3 cleaner went back to No. 2.

X Q. 42. Now, these cells, 4, 5, 6 and 7 of the No. 2 cleaner, were they provided with the pneumatic attachment that characterizes what is known as the Janney mechanical pneumatic machine?

A. They were.

X Q. 43. That is true of course of all the pyramid machines.

A. In all of the pyramid machines the last four are provided with the pneumatic equipment.

X Q. 44. Now, in the operation of No. 2 cleaner the pulp flowed successively to it from spitzkasten to spitzkasten in the usual way?

A. It did.

X Q. 45. And of course in your pyramid machines, they flow down by gravity?

A. They do.

X Q. 46. From spitzkasten to spitzkasten?

A. Yes.

X Q. 47. Now, in the No. 1 cleaner, did the material
3875 treated flow from spitzkasten to spitzkasten in series?

A. There is practically only one spitzkasten for that cleaner.

X Q. 48. That is to say the partitions between the spitzkasten do not extend down very far, do they?

A. They do not.

X Q. 49. How far do they extend down below the top?

A. About ten or twelve inches.

X Q. 50. Then below that on both sides it is all one large spitzkasten, is that right?

A. Yes.

X Q. 51. Then No. 2 agitator for No. 1 cleaner, where does it draw its supply of material to be agitated?

A. From the spitzkasten.

X Q. 52. And that is true all along the line there?

A. It is.

X Q. 53. How about No. 3 cleaner?

A. That is the same as No. 1 cleaner.

X Q. 54. Then in the No. 3 cleaner the spitzkasten are entirely separate in each cell—the spitzkasten for each cell is separated from the spitzkasten for the other cells?

A. No, it is just like No. 1.

X Q. 55. That is to say, it is all one general spitzkasten?

A. Yes.

X Q. 56. Now, was that arrangement an arrangement made on that day, or how long had it continued?

A. That had been made for—that had been running that
3876 way for—well, the last time I was up to the plant was several days before then, and it was running then, but I did not give it any general inspection because I was busy down here; but we have run this many times like that before, and it has been arranged several months ago to use this No. 8 pyramid as a cleaner. There was no special arrangement made for any part of the operation on Sunday.

X Q. 57. In your No. 2 cleaner, and I think in all your pyramid machines, I observed a substantial difference in the top of the spitzkasten between the cells Nos. 1, 2 and 3 and Nos. 4, 5, 6 and 7. Suppose you describe that difference.

A. Well, that is due to the fact that the spitzkasten of cells No. 1, 2 and 3 are deeper than the spitzkasten for 4, 5, 6 and 7, and the construction was placed that way.

X Q. 58. You have not described it.

A. The first three cells are mechanically agitated only. The last four cells are mechanical and air, consequently it is not necessary to have as deep a spitzkasten for mechanical and air as it is for straight mechanical.

X Q. 59. I notice that your flow was restricted as it came out of cells 4, 5, 6 and 7; that the sides of the top of the spitzkasten approach together so that the overflow was quite restricted; that is the construction, is it not?

A. It is.

X Q. 60. Whereas in 1, 2 and 3, they are of the full
3877 width throughout and the overflow lip was the full width of the spitzkasten?

A. That is correct?

X Q. 61. Then in cells 1, 2 and 3 you have a mechanical arrangement somewhat resembling a paddle for pushing the concentrate over the lip?

A. That is correct.

X Q. 62. And in cells 4, 5, 6 and 7 it rushed off the restricted lips without any assistance?

A. That is right.

X Q. 63. Now, you used your mechanical arrangement for pushing the concentrate over the lips in No. 1 and No. 3 cleaner, do you not?

A. That is correct.

X Q. 64. Can you tell me why it is that the spitzkasten for all the pyramids except No. 5 were put out of action?

A. That was done to relieve the elevators, and to reduce the middling that was returned back for circulation and retreatment. It reduced the load approximately one-half.

X Q. 65. Now, as this plant was operated on Sunday in our presence, what was the place of the oil feed of the plant; is that shown?

A. It is shown substantially the same as on my previous flow sheet.

X Q. 66. Marked "oil feed"?

A. Marked "oil feed."

X Q. 67. And that—at that oil feed the oil was fed in hot, was it not?

3878 A. Well, I should say warm; warm enough to keep it plenty liquid.

X Q. 68. You have a steam heating arrangement in your oil mixer, have you not?

A. It is absolutely necessary, yes, sir.

X Q. 69. Have you any figures as to the temperature at which the oil goes into the plant?

A. I have not, off-hand, no.

X Q. 70. And the water as it flows through the plant is quite cold, is it not, and you do not heat that at all?

A. We take the chill off of it at times.

X Q. 71. You were not on Sunday last taking the chill off of it?

A. I don't remember what the temperature was Sunday; it might have been about 14 or 16 or 18 degrees. We don't make any particular effort to heat it or not heat it, only on cold nights we can not allow the cold water to run through.

X Q. 72. You don't want it to freeze?

A. No, I should say not.

X Q. 73. Therefore you guard against freezing?

A. Yes.

X Q. 74. Have you got with you the mill reports of operations of the plant on Saturday the 28th, Sunday the 29th and Monday the 30th of April?

A. No, I haven't brought those with me.

X Q. 75. Will you bring those reports—I believe I asked you to bring some other reports, did I not?

A. Yes.

3879 X Q. 76. Have you them with you?

A. Yes. I might say that these reports of the operation on Sunday are being prepared and I think will be finished some time tonight; and possibly the men who are preparing them now will have them finished in time to submit them tomorrow.

X Q. 77. Could you include the day before and the day after?

A. I will do so if you desire.

Mr. Scott: I offer the flow sheet in evidence produced by the witness, as representing the operations on Sunday, April 29th, 1917.

Flow sheet admitted in evidence marked Defendant's Exhibit No. 222.

X Q. 78. What are these records which you have brought and are now exhibiting; when do they commence?

A. They commence prior to September 30th, 1913, and as I understand it you wished some one day, November 1st, 1913, or October 1st?

X Q. 79. Well, let us take September 30th, 1913. Give me the ore milled, what is that figure?

A. The ore milled on September 30th, 1913, was 1,308 tons.

X Q. 80. And that was the total amount of ore milled in the plant, was it?

A. That was the total amount of ore milled in the entire mill.

X Q. 81. So that a part of that ore went through the water concentration, and some concentrate was taken off, and the
3880 balance of it went to your flotation plant, is that right?

A. Exactly so.

X Q. 82. Now, give me the amount and grade of concentrates in the wet concentration plant for that day.

A. It is impossible to give it to you for that day, because I have no record of it. I have a record of the assays, but as to the amount, I can not differentiate from what is produced in the flotation, only an estimate; but the average zinc concentrate I can give you.

X Q. 83. What is the zinc produced in, tons; is that the total of the plant?

A. Yes.

X Q. 84. How much is it?

A. 505 tons.

X Q. 85. And the lead concentrate produced?

A. Six tons.

X Q. 86. General heads, moisture percentage?

A. 2.0%.

X Q. 87. General head, lead?

A. 1.2%

X Q. 88. General head, zinc?

A. 21.9%.

X Q. 89. General tails, lead?

A. .18%.

X Q. 90. General tails, zinc?

A. 4.1%.

X Q. 91. Zinc concentrate, lead?

A. 1.9%.

X Q. 92. Zinc concentrate, zinc?
3881 A. 50.3%.

X Q. 93. Lead concentrate, lead?

A. 48.4%.

X Q. 94. Lead concentrate, zinc?

A. 17.2%.

X Q. 95. Indicated recovery?

A. 88.59%.

X Q. 96. Apparent extraction, zinc?

A. 88.50%.

X Q. 97. The item of estimated recovery is not filled in under the day; is that right?

A. That is right; it is not filed in for the particular day, as we keep the apparent estimated recovery up to date, for the whole month, to date, from day to day.

X Q. 98. Give me the figures of the flotation output in shifts.

A. The flotation concentrate assay by shifts was for the first shift, 49.5% zinc; for the second shift, 48.3 zinc; for the third shift, 50.8% zinc.

X Q. 99. And isn't there a separate figure for the water concentrate?

A. Yes.

X Q. 100. Read that.

A. The zinc produced in the water concentration end of the mill for the first shift assayed 52.3% zinc; for the second shift, 51.8% zinc; for the third shift, 50.6% zinc.

X Q. 101. Is the total of the concentrates given?

A. No, only as a total, the combined flotation and mill zinc?

3882 X Q. 102. What is that?

A. 505 tons.

X Q. 103. Now the amount of oil used, read that by shifts.

A. I haven't got it by shifts, but the oil used on that day was—I don't know whether that figure is right or not; it says 13.79 pounds of oil per ton.

By the Court:

X Q. 104. Was that after December 26th?

A. No, this was September 30th, 1913. It says on that report that there was 18,044 pounds of oil used that day.

X Q. 105. Let's see how many were used the next day.

A. Well, the day previous, I see the report says there was 1,742 pounds used.

X Q. 106. And the percentage of that was what?

A. 1,676 lbs. per ton.

X Q. 107. Take the day ahead, September 28th.

A. The amount of oil used on the 28th was 1,800 lbs., or 1,751 lbs. per ton.

X Q. 108. Aren't you inclined to believe that there is a mistake in the return for September 30th, 1913?

A. Well, I have not looked at this thing for a long while, and I just got these reports out.

X Q. 109. I will ask you to check it up over night, if you will.

A. Very well.

Mr. Scott: If the court please, I would like to have the record show that we invite plaintiff's representatives to witness

3883 a repetition of the test with 323 lbs. of oil, that Mr. Janney testified to, and we will be willing to do it on Sunday next or any other Sunday or any other time that will be suitable and agreeable.

Mr. Garrison: At your plant here?

Mr. Scott: At Salt Lake City, or at Garfield.

Mr. Garrison: Oh, no, that is unreasonable.

The Court: The record may show it; I don't know how much weight we will attach to that kind of an offer. It might be in Alaska next time.

Mr. Kremer: If your honor please, I have got here the answer to tthe plaintiff's bill as amended, and I have also an answer to the supplemental bill of complaint. Under the rule, notice was given by counsel that the portion of the amendment as embodied in the application to file the supplemental and amended bill, was noticed to become a part of the original bill, and under the rule, giving page and line; therefore it automatically became incorporated in the bill as amended. For that reason we have prepared a separate answer to tthe original bill as amended. That left the supplemental bill, having expunged from it paragraph 8, that having become a part of the original bill, and we now file an answer to that. In this connection I will state to the court that we expect to close our case tomorrow, and I have endeavored to have these answered prpared—I asked your honor if we had all day tomorrow, but I thought it better to have them prepared so that counsel would have them before we close our case. They have very kindly consented that if there is any
3884 mistake in the transcribing from the original pleadings heretofore filed, that we may have permission to make corrections of those things.

Mr. Williams: Yes.

Mr. Kremer: I thought it would be better to give them an opportunity to examine them over night, before we close our case.

Whereupon further hearing was adjourned until Saturday morning, May 5th, 1917, 10 o'clock a. m.

Saturday, May 5, 1917—10 a. m.

Mr. DOSENBACH.

Cross-examination resumed.

By Mr. Williams:

X Q. 110. At the close of the session yesterday you observed that the record for September, 1913, seemed to contain an unusual amount of oil, and I asked you to check that up over night. What have you learned in regard to that?

A. As far as I could get any more information on that matter—I endeavored to find out just why there was a difference between the 30th and the 29th in the amount of oil per ton of ore, and the only thing that I could find was, it being the last day of the month. I could not find any records wherein it showed any real reason
3885 for its not being what it is, other than the last day of the month.

X Q. 111. That is to say, a sort of accumulation of the errors of the month, to check up the total month's consumption?

A. Yes.

X Q. 112. Let us have, then, the average for the month.

A. The average for the month was 2.799 lbs. per ton of ore milled.

X Q. 113. Does this record show the character of the oil?

A. This record does not show the character of the oil.

X Q. 114. Now, turn back to the last day of August. What was the record on that day as to oil used per ton of ore milled?

A. The record for August 31st, 1913, shows 2.561 pounds of oil per ton of ore milled.

X Q. 115. And the record for the preceding day, August 30th, 1913?

A. It shows 1.237 pounds of oil per ton of ore milled.

X Q. 116. On the date ahead of that?

A. 2.470 pounds per ton of ore milled.

X Q. 117. I notice that on September 30th there is no acid determination; what does that mean?

A. Well, there was possibly some reason for it; I don't know what the reason might be. It is not on here for September 30th.

3886 X Q. 118. But for September 29th you have an acid determination?

A. Yes.

X Q. 119. What is the proportion of acid?

A. The amount of acid is 8.065 pounds per ton or ore milled.

X Q. 120. Now, on August 31st, 1913, what was the acid?

A. 2.139 pounds per ton of ore milled.

X Q. 121. August 30th?

A. 7.364 pounds per ton of ore milled.

X Q. 122. And the average for the month of August was 5.816 pounds per ton of ore milled.

A. Yes.

X Q. 123. Now, you have said that the record does not show the character of oil that was used then, but I believe you are acquainted with the fact, are you not?

A. I think I have stated before that during this period two oils were used, the pine oil and oleic acid.

X Q. 124. In August, 1913, you have an item "Copperas, Pounds, and Lime." That is the sum total of the copper sulphate and lime used?

A. No, that is lime only. This was not scratched out. We used no copperas then.

X Q. 125. What was the amount?

A. The lime used was .373 pounds per ton of ore milled.

X Q. 126. August 29th, I see also it is copperas, pounds, and lime.

A. Well, it is lime only, because we did not use any copperas then; it was lime.

3887 X Q. 127. And the amount?

A. .363 pounds per ton.

The Court:

X Q. 128. How long did you testify that the conditions of this flow sheet you exhibited had prevailed?

A. The one I testified to yesterday?

The Court:

X Q. 129. Yes.

A. Why, that has prevailed for the last two or three months. Previous to that, while the machines were of different construction and differently placed as to the relation of one cell to another, there being three machines before and eight machines now, however, the three machines had a greater number of cells than each one of the eight has now; but they were the same machines that had been in use before only arranged differently as to the position of one to the other.

Mr. Williams:

X Q. 130. Now, have you the reports of the operations on Sunday, April 28th?

A. Mr. Shimmin has the reports for that and he was to be here at ten o'clock this morning.

X Q. 131. And you haven't them?

A. No, I haven't them; I haven't had time to make them up personally.

X Q. 132. I asked you for an analysis of the copper sulphate that you received from the Anaconda Company, have you that?

A. I think I have that in my notes upstairs, in one of my notebooks. I did not remember that I was to furnish that, but it will take only a minute to give it to you.

3888 X Q. 133. You were to give me an early analysis of the zinc in the total feed to the plant, including the circulating load. Have you that?

A. As I remember you asked me for December and November, 1916, and also for December, 1915, so I wish to say that the average for the month of December, 1915, showed 12.16 per cent zinc.

X Q. 134. And this was the amount of zinc in the total feed, including the new feed in the circulating load, is that right?

A. That is right. Then for November, 1916, the amount of zinc in the feed, including the middlings, was 11.9 per cent zinc.

X Q. 135. And for December, 1916?

A. The amount of zinc in the flotation feed, including the middlings, was 12.5 per cent zinc.

X Q. 136. And as to all three of these months the variation up and down from that average was very slight.

A. It was.

X Q. 137. You were to give me an analysis of the molybdenite ore that you used in the experiment in court. Have you that?

A. I haven't them, Mr. Williams, because it has not been finished yet.

X Q. 138. Now, in regard to September 30th, 1915, is there any showing on the record of the temperature in the flotation plant?

A. On December 30th?

X Q. 139. September 30th, 1915?

A. No. And to get that I can give you approximately the
3889 temperature which we were operating at that time.

X Q. 140. What was it?

A. About thirty to forty degrees centigrade, somewhere along in there.

X Q. 141. And when was the introduction of heat or the heating of the pulp eliminated?

A. We eliminated it quite a number of times, but we always kept a little steam there to take the chill off the water, especially in the winter time. But up to 1915, the middle of 1915, say, we used more steam than we did after that time.

X Q. 142. Well, what were the temperatures prevailing in the plant in December, 1916, before December 22nd, 1916?

A. Before the 22nd of December, 1916, the temperature was about 35° or 36° C.

X Q. 143. Now, since December 22nd, 1916, what have been the temperatures of the pulp?

A. From 14 to 40° I should say, but at the present time averages close to 14 and 18 degrees; closer to that than the higher temperature.

X Q. 144. Was there any particular reason for so large a range of temperature?

A. The only reason was that we tried out a high temperature at various times and a low temperature at various times and found it was not necessary to use any higher temperature than we were using.

X Q. 145. So that you have come down to this low temperature of fourteen or fifteen degrees centigrade as the best temperature to work at?

3890 A. Well, at this time, yes.

X Q. 146. What methods are used at your plant for the determination of the amount or character of oil in the different products?

A. Well, I am not in a position to state myself what analytical methods are used for that determination. We have an oil chemist who looks after all of those details and I cannot myself state just exactly what he does. However, in a general way, he uses a distillate fraction method of determining certain oils and also the centrifuge and other apparatus for determining other oils in the mixture.

X Q. 147. What was the general plan and object of determining all of the oil, dissolved and undissolved in the wet analysis that attached to the products?

A. Well, we determine all of the oil that is in the product. The sample of the material goes to the oil chemist in a wet state and he receives it in a wet state and determines all of the oil that is present, and makes his determination relative to the amount of dry material.

X Q. 148. Where did you purchase the kerosene which was used in the plant on April 29th?

A. I would have to look that up to be exact about it, but we pur-

chased most of our kerosene from the Continental and Salt Lake, Utah.

X Q. 149. When you receive this kerosene, do you give it any treatment or do you add anything to it before you mix it with the other oils?

A. We do not attempt to add anything to it or give it any
3891 treatment before we mix it with the other oils. Sometimes we have no tanks available and we have to use a tank that has contained other oils, but then that is very seldom. It is quite a hard problem to take care of all these different oils that come in and it is necessary sometimes to put the kerosene as well as other oils into tanks that have contained different oils.

X Q. 150. But nothing is mixed with that kerosene or added to that kerosene except the other oils with which it is used, is that right?

A. Nothing that I know of is mixed, and I think I would know of it if there was.

X Q. 151. Now, was the kerosene that Mr. Phillips used in his experiments the same as the kerosene which was used at the plant?

A. Practically so, yes.

X Q. 152. What difference is there?

A. I don't know of any difference. Might be a little difference in the small sample he used as compared to the large sample up there.

X Q. 153. Was there anything put into it?

A. There was not, to my knowledge.

X Q. 154. Where did the laboratory sample used by Mr. Phillips come from?

A. It came from the stock bottle in the stock supply at the plant.

X Q. 155. And so far as you know, the oil that Mr. Phillips used, the kerosene, was the same kerosene that was used in the plant?

3892 A. Well, I may make that statement this way: that so far as I know the kerosene that Mr. Phillips used was practically the same kerosene that I used in my tests here in which I used kerosene, in court, and as to being the same as we use at the plant, it is supposed to be the same but there may be a little change due to age or something like that. It may be a little older sample, but as to anything being put into it or it being contaminated in any way with other oils, that, so far as I know, is not so.

X Q. 156. And the oil that you used here was oil obtained from the supply at the plant?

A. Yes.

X Q. 157. Now, do you remember anything else that I asked you to bring and have not asked you about?

A. Yes, you asked for some detailed information as to the month of February.

X Q. 158. Will you supply that now?

A. I will be glad to. I think you will find everything on this report that is necessary.

X Q. 159. This is a full statement of the different days' proceedings in the month of February, 1917, is that right?

A. That is correct, as far as the flotation plant is concerned.

X Q. 160. And was this prepared by you from the original records?

A. Yes.

3893 X Q. 161. And these remarks, were they taken from the record?

A. Yes, they were taken from the record. That was for my own information. I found them there and copied them.

Mr. Scott: We offer the report produced by the witness in evidence, entitled "Butte & Superior Mining Company, Flotation Plant Operations for Month of February, 1917," this being a statement of the operation for each individual day.

Table admitted marked Defendant's Exhibit No. 223.

X Q. 162. Is there anything else that I asked you for that you have not supplied?

A. Not that I remember. You asked for the flow sheet, and for a report from February 4th to 28th, but that is included in this report for February. I would like to say, though, that in giving you the amount of oil used per ton in September, 1913, and other days along in that period which I have taken from this daily general mill record, that is the amount of oil used per ton of ore milled, and not per ton of flotation feed. It is based on the actual tons of ore milled.

X Q. 163. But the difference in the figures would not be very great, would it, between the total ore milled and the new feed to the flotation plant?

A. It would not be very great, no, so it would not make a great deal of difference in the amount of oil to the flotation plant. I just wished to correct that statement, though, in case it was mis-

3894 understood.

X Q. 164. Well, what would the average difference be in points?

A. I can give you a rough average of that; it would possibly make between five and seven per cent. difference, or a little greater; that is, the amount itself, if it was 1½%, for instance, it would be 5% off the 1½%.

X Q. 165. Now, in this table that you have produced, exhibit 223, you have not included the total of the concentrates, and you have not included the total of the new feed?

A. Yes, that is included in the table that I have presented, another table before this, which gives the total of flotation feed, the tonnage of flotation concentrates for each one of those days for the month of February.

X Q. 166. I notice that in this exhibit 223 there is a repeated statement of considerable trouble with the elevator. What was the cause of that trouble and what was it?

A. Well, it might have been due to many things. The trouble with the elevator possibly was due to the splicing coming loose, or it may have been due to some mechanical condition of the boot pul-

ley or the head pulley; it might have been due to overloading with feed.

X Q. 167. I see your last remark is "overloading feed to elevators, unable to handle return feed."

A. Well, it might have been due to that, if the elevator—
3895 They might have become overloaded, and conditions of flotation were very poor during that time.

X Q. 168. And the correction of that would be to cut down the return feed?

A. Well, it would be to cut down the original feed, and therefore that would cut down the middling or return feed.

X Q. 169. Well, you showed in your flow sheet yesterday a method of cutting down the middling return by putting a certain number of boxes out of operation, did you not?

A. That is one way of cutting it down all the time, but if it is running too high with those boxes cut out, then there would have to be some other method of reducing the overloaded condition.

X Q. 170. Did you, during February, cut out some of the boxes in order to diminish the return feed?

A. No, I don't think so.

X Q. 171. When did you commence to do that?

A. I think that was in March.

Mr. Williams: Nothing further at present.

Redirect examination.

By Mr. Scott:

R. Q. 172. Will you describe the model machine which you have had made, just generally, and you can go more into detail with these drawings, but just a general statement of what it is.

Mr. Scott: I simply propose a general description from
3896 the witness with reference to the flow sheet, because it is so difficult to get it on the record when we are looking at the machine itself. When we get this general description in, then he can amplify it.

A. The model machine which I have had made is a flotation unit in itself, and consists of a rougher having seven cells and three additional agitators, which produce a rougher concentrate and a middling product, the same as is produced in actual flotation operations. This model unit also consists of a cleaner and a recleaner. The middling product from the rougher—the rejected product from the cleaner and recleaner are returned to the head end of the rougher cells by means of an elevator. This unit also consists of a feed tank, or what we commonly call a sludge tank, which supplies the feed to the first cell and also takes care of the return middlings, such as the middlings from the rougher and the tailing from the cleaner and recleaner. This machine shows in itself the working of a unit in flotation, therein all of the products are taken care of; the

middlings are returned as is done in actual practice; the tailings are rejected and concentrates are produced on the cleaner cells.

R. Q. 173. I hand you this flow sheet which you have prepared and ask you to explain to the court the flow of the material, and you may at the same time, if you desire, refer to this sketch which you have had made.

Mr. Scott: I offer the flow sheet.

The flow sheet marked Defendant's Exhibit No. 224.

3897 Mr. Scott: I offer the perspective sketch of the machine.

Perspective sketch marked Defendant's Exhibit No. 225.

Mr. Williams: We reserve our objection to these.

A. Referring to the flow sheet of the model flotation plant, Exhibit 224, I will now endeavor to show the flow of the material through this complete unit. To begin with, the ore and water are placed in the sludge tank, which is the feed tank for the original feed, and that tank discharges into the pulp elevator, which is this elevator here on 225, where it is elevated to the first agitating cell, which is Cell No. 1. The material then passed through these three cells in series and into the fourth cell, which has in direct connection a spitzkasten. Now, we have seven cells with spitzkasten, which we will call the rougher cells, these three previous agitating cells are emulsifiers; these seven cells are rougher cells, producing rougher concentrate and middlings. The first three cells produce a rougher concentrate, which is retreated in a cleaner cell down below, which is this cell on the perspective view.

R. Q. 174. State how the pulp goes from one cell to the other.

A. It flows from one cell to another by gravity; there being a difference in elevation between the first and second and second and third and so forth on down through and including the seven,
3898 so that the upper one is higher than No. 2, and therefore the flow of the pulp is by gravity into the succeeding cells.

R. Q. 175. Where is the passage?

A. The passage is in the corner of the spitzkasten.

R. Q. 176. And runs to where?

A. Directly into the agitating cell of the succeeding cell.

R. Q. 177. Does this illustrate the movement of the pulp here?

A. It does; the movement of the pulp is from your first agitating cell, which is in direct connection with the spitzkasten, into that spitzkasten; from that spitzkasten into No. 2 agitating cell, and from that cell into the same spitzkasten, which is directly connected with it; and from No. 2 spitzkasten into No. 3 agitating cell, and so forth on down the line, until the final tailing is made by No. 7 spitzkasten. That would be from this agitating cell to this spitzkasten, and from this spitzkasten into this second agitating cell, and into the second spitzkasten, and so forth on down the line.

Now, the concentrate that is produced in number one cleaner is retreated again and purified in the No. 2 cleaner, which produces a finished concentrate. The rejection or tailings from each of these

cleaners, and from both of them, joins with the middlings that is produced by the last four rougher cells and goes back again into the elevator where it is elevated with the original feed to the first agitating cell. So, in this unit we have after starting and in con-
3899 stant operation, we have this battery of seven rougher cells treating the original ore plus the return middlings as shown, which is done in actual practice. The middlings are retreated in actual practice with the original ore.

The Court: Tailings only from the seventh?

A. Tailings only made from the seventh cell and the tailings from the cleaner and recleaner are returned again. They contain more mineral than the middlings that are produced by the last four cells of the rougher—that would be these last four cells as you look at the machine, facing you.

Mr. Scott: Now, if the court will consent to go to the Grand Jury room we will be prepared to operate the machine, and in connection with the operation the stenographers inform me that it is almost impossible during the operation of the machine to make any record, so I would suggest that such explanation be made there as necessary to enable the court to understand the machine and then afterwards Mr. Dosenbach can take the stand when we return to the court room and put it in the record. I make this statement because the stenographers seem to despair of getting down all that is said while the machine is being operated and numerous questions are being asked. If that is agreeable to the other side I suggest we proceed that way.

Mr. Williams: If it is agreeable to the court.

The Court: Yes.

Mr. Williams: In view of the fact that you have a large machine that has a great many parts and at which things occur, I
3900 would like to send up a sufficient number of representatives to be able to watch the operation. One man cannot watch that machine.

The Court: There is no objection.

The Witness: You mistook my statement, because if I was to proceed ahead of you to get ready in the two minutes it would take to get up there, you might send one man along to see that I get up there safely.

2 p. m., May 5th, 1917.

R. Q. 178. Mr. Dosenbach, will you describe your procedure in operating the model plant which you operated this morning?

A. The operation of the model flotation plant in which the experiment was performed this morning was as follows: 146 pounds of water at a temperature of 16° C. was added to the sludge tank. The agitators and elevator and mechanism in the sludge tank was then started and 60 pounds of Butte & Superior ore were added to the water in the sludge tank. This formed a pulp of 146 pounds of water and 60 pounds of ore. Next, 65 cc. of sulphuric acid was added, together with 78 cc. of copper sulphate solution to this pulp

in the sludge tank. The pulp was then circulated through the elevator and through the rougher cells until thorough mixture was obtained, and the oil was then added to the first agitating ore emulsifying cell. The total amount of oil added was 665 cc. This oil is equal to 574.6 grams, or the total amount of oil used in the test was 1.266 lbs., which is equal to 2.11%, or 42 lbs. of oil per ton of ore.

3901 The copper sulphate solution used was the regular copper sulphate solution that is used at the Butte & Superior flotation plant, and was equal to 7.4054 lbs. per ton, or 0.1 pounds metallic copper per ton of ore. The sulphuric acid used was commercial sulphuric acid, 59° Be., and the quantity used as stated before, was 65 cc., which was equal to approximately 8 lbs. of sulphuric acid per ton of ore. The oil was added to the pulp as it flowed through the cells; however, there was no tailing made during the time that the oil was run through the machine, in order that all of the oil should be thoroughly mixed up with all the feed as much as possible, so that when the feed became steady, it would have practically the same amount of oil in it as it continued to enter the machine. The gates were so regulated so that during the time the oil was being fed through the machine there was no concentrate or tailing made, consequently all of the pulp was circulated through the elevator and returned back through the machine again and to the sludge tank. After the oil had been entirely fed to the ore pulp, the machine was then regulated so that an overflow occurred on the first three spitzkasten and on the last four spitzkasten, and the tailing gate was opened and the tailings were then made and discharged regularly from the seventh cell of the rougher machines. A very copious mineral froth occurred on practically all of the cells at first. Later on the froth on the first three cells was much heavier than the froth on the last four cells, and on the seventh cell there was very little froth, as the mineral was being taken off on the first three cells.

3902 There was a gradual graduation of the amount of mineral contained in the froth from the first spitzkasten on down through the seventh spitzkasten, showing that in these later cells of the rougher series there was less mineral, consequently there was less froth. Samples were taken of the tailings and the concentrate, there being four special samples on the tailing and concentrate taken which represents fairly well the average of the machine. But the main purpose in demonstrating and showing the operation of this machine was to illustrate the flow of material through an operating unit which is very similar to that used at the Butte & Superior, in the matter of flow, and also to show the froth and character of froths that was formed in using oil equal to 42 pounds of oil to the ton. The operation of the cleaner and recleaner was somewhat erratic and consequently the froth and material in the cleaner and recleaner was not consistent and did not overflow continuously on account of the discharge gates and openings from these cells soaking up, causing the cells to drain very rapidly and also to fill up very quickly. The feed to the rougher cells was also somewhat erratic at times on account of the belt on the elevator slipping and giving quite a lot of trouble during the run.

R. Q. 179. What was the oil mixture that you used this morning?

A. The oil mixture used was 70% fuel oil, 18% pine oil and 12% kerosene and was the same oil mixture that is—that was used at the Butte & Superior plant on April 29th.

3903 R. Q. 180. That was the Sunday when the representatives of the plaintiff visited the mill?

A. On the Sunday when the representatives of the plaintiff visited the mill.

R. Q. 181. And what was the rate of flow of the pulp through the machine? I suppose you have stated in that terms of the solids, have you not?

A. Well, the rate of flow would average about a ton of ore every 24 hours—possibly more. That is just a guess on my part. I have made no tests to determine the capacity of the machine.

R. Q. 182. Well, what would you say that would amount to in a minute? Something over a pound a minute, wouldn't it be?

A. Yes.

R. Q. 183. And you had in it 60 pounds this morning?

A. Sixty pounds.

R. Q. 184. On that estimate it would take something like in the neighborhood of how long for the complete material to circulate through it once?

A. Well, it would be a pound a minute practically and therefore in an hour there would be sixty pounds circulate through it, but the sixty pounds was increased somewhat by the circulating load of middlings, which increased the total amount going through the machine.

R. Q. 185. This copper sulphate solution that was used, was that the same as was being used on Sunday, April 29th?

A. It was.

3904 R. Q. 186. And how does the proportion you used this morning compare with that which you used on April 29th?

A. Well, the proportions that I used this morning was in the same proportion of ore as in all of the tests that have been run in the court's demonstration and it would be a fair average of what our operations consist of.

R. Q. 187. At the mill?

A. At the mill, that would be one-tenth of a pound of metallic copper per pound of ore.

Mr. Scott: You may cross-examine.

Recross-examination.

By Mr. Williams:

R. X Q. 188. How about the speed determinations that you made?

A. I took the speed of the agitator shaft to be 1988 revolutions per minute or 1561 peripheral feet per minute.

R. X Q. 189. You had successive agitators rotating in different directions, didn't you?

A. Yes.

R. X Q. 190. What was the effect of the inclination of the blades?

Was it in every instance to tend to force the liquid upward, having in mind the direction of rotation.

A. No, it was not. The machine at first was built to work with a rope drive running around each one of the agitator shafts
3905 as shown in the perspective drawing, and that did not give us good satisfaction, so it was changed to individual drives for each one of the agitator shafts. Consequently, working with a rope drive such as is shown in that descriptive drawing, one shaft will revolve in one direction and the other shaft will revolve in the other direction, the one following the first one.

R. X Q. 191. Well, now, did you maintain the same direction of rotation that is shown in your drawing here, that is successive agitators revolving in opposite directions?

A. Well, I haven't given that any attention at all, I don't know whether it is myself. In fact I never paid any attention to it. These belts were all taken off and put on again several times. Of course they would have to be maintained because otherwise you would have your agitator blades revolving in the wrong direction.

R. X Q. 192. Well, what is the right direction for these agitator blades, as to the manner in which they incline as presented to the pulp.

A. With the face up.

R. X Q. 193. That is tending to force the liquid up?

A. Yes.

R. X. Q. 194. And as the machine was originally designed and operated, as shown in your drawing, exhibit 225, were the successive agitators with reverse arrangements so that they would all tend to throw the liquid up?

A. All the agitators tended to throw the liquid up.

3906 R. X Q. 195. How long a time was consumed in the operation which you carried on this morning?

A. About an hour and ten minutes.

R. X Q. 196. And during that operation how many times was the pulp circulated through the machine?

A. Well, I couldn't say as to that. It would be something like—it would be in actual practice, and I can't say what that would be because some of the pulp in the flotation or in any milling operation, goes through an innumerable number of times, while others go through only for a short time. So I have no way of judging as to how long any part of it was in circulation.

R. X Q. 197. But in fact as you operated the machine at first, sending the rougher concentrates back and through the machine, these rougher concentrates must have gone through several times, must they not?

A. Oh, no doubt they did go through several times.

R. X Q. 198. That is to say they were taken off and sent back immediately as being less in bulk, then released ahead of the tailings that were sent back? Is that an expression of the situation?

A. No, the middling was not sent back. In fact there was no overflow on the first three cells while the entire feed was in circulation. It was only overflowed from—it was only the overflow from

the last four cells which was returned and sent back through for circulation. There was no tailing made at that time, consequently all of the feed that came into the cells was sent back again.

3907 R. X Q. 199. And you maintained that condition of returning everything throughout the time that you were feeding the oil to the machine?

A. I did.

R. X Q. 200. And some time beyond that?

A. Until we could get conditions regulated, yes, sir.

R. X Q. 201. Were these conditions in that machine at any time regular conditions?

A. Yes, they were, for a short time. We had considerable trouble this morning, I will admit that, but that is a condition which might exist at any time; in fact it was very similar to the questions you asked me this morning what might happen to the elevator. It showed what might happen in an actual plant, what happened up there.

R. X Q. 202. These elevators were not overloaded were they—or this elevator was not overloaded?

A. It might have been, and I might have started it.

R. X Q. 203. Do you maintain any definite time when that machine upstairs was operating in a normal manner?

A. Why, I think it was operating in a normal manner for a great part of the time, with the exception of the cleaner and recleaner. The rougher certainly was operating normally. The cleaner and recleaner choked up considerably, and it was necessary to clean them out, but the rougher cells operated normally for quite a period, and that was the main part of the run, I thought, was to illustrate the gradual gradations of the mineral froth on the various cells.

3908 R. X Q. 204. Now, after you had got the oil in and were satisfied that you had reached proper conditions in the rougher cells, did you feed all of the overflow from the rougher cells down to the cleaner and recleaner, and did you continue that through the operation?

A. Yes.

R. X Q. 205. And the irregularity was in the cleaner and recleaner; they got choked up; that was why the feed was so irregular?

A. That was why the feed was so irregular.

R. X Q. 206. Of course the consequence of that was that the concentrate of the last machine, the recleaner, would accumulate for quite a time, and then come out in bunches; that was, I suppose, a description of what happened?

A. That condition existed at one time there that I know of, when I looked down that way and saw it; on account of the discharge gate or opening leading from the recleaner cells choking up.

R. X Q. 207. Of course in the regular operations the tailings go to waste, do they not?

A. They do.

R. X Q. 208. And you got to the condition nearest approaching regular operations when you were sending your tailings out into the tailings receptacle?

A. Yes.

R. X Q. 209. I noticed in the table that you put in this morning, defendant's exhibit No. 223, that I asked you for the per-
3909 centage of oil in the tailings, which is the next to the last item; that for the 27th of February is wholly different from any other item; can you explain that?

A. Which one is that?

R. X Q. 210. You have, for instance, on the 28th 0.45; on the 27th 0.062; on the 28th 0.68. Now, that 0.062 seems to be very erratic. What do you think of that?

A. It is an error; it should be 0.62.

R. X Q. 211. I have made the correction in the original exhibit. Now, isn't it a fact that that column showing the amount of oil in the tailings shows that you are running to waste in the tailings more than twice as much oil as you used before December 22nd?

A. It does; sure.

Redirect examination.

By Mr. Scott:

R. Q. 212. Mr. Dosenbach, are there any more things which Mr. Williams inquired about that you have?

A. No, I think that is all, with the exception of some assays that are not completed, and the returns are not out.

Mr. Scott: I offer in evidence the machine which Mr. Dosenbach operated this morning.

Machine admitted without objection marked Defendant's Exhibit No. 226.

3910 Mr. Scott: I offer in evidence the flow sheet marked 224, and the drawing, exhibit No. 225.

Exhibits 224 and 225 admitted without objection.

Mr. Williams: I should say, in regard to the machine, on behalf of the plaintiff, that as an illustrative model of something in which the flotation process may be carried out, there is no objection to it. As a representation of what is practically our standard machine there is no objection to it. But if the defendant is relying upon it as a representation of anything in the prior art, then we object to it as wholly irrelevant. With those qualifications it may be admitted.

The Court: Well, of course, it is like the other exhibits; it is in for all purposes that it ought to serve, and they may be pointed out in argument.

J. T. SHIMMIN recalled on behalf of defendant for further

Direct examination.

By Mr. Scott:

Q. 1. You are Mr. J. T. Shimmin who testified before?

A. Yes.

Q. 2. You have a report, I believe, of the operations of the Butte

& Superior flotation plant on Sunday, April 29th, from 1 to
3911 5 p. m., during the interval when the representatives of the Minerals Separation Company were present?

A. Yes.

Q. 3. And this is the report?

A. That is the report, yes, sir.

Q. 4. Were these operations conducted under your charge?

A. Yes.

Q. 5. And those reports are the regular reports prepared in the ordinary course of the administration of the plant?

A. Well, they are more complete, but we keep practically the same record of all our operations.

Q. 6. To the best of your knowledge and belief this is a correct report of the operations referred to?

A. Yes, sir.

Mr. Scott: I offer the report referred to by the witness in evidence.

Report admitted and marked Defendant's Exhibit 227.

Mr. Williams: As far as I can see, your honor, this repeats the testimony of the witness as to things that occurred, but I have no objection to it provided we upon examination find that it is all right. It is a long document. It may facilitate matters to have it in the record.

3912 Cross-examination.

By Mr. Williams:

X Q. 7. Mr. Shimmin, is this a report for the whole day?

A. No, it is just the period from 1 to 5 p. m. of the 29th.

X Q. 8. Where is your report of the whole day, the regular official report?

A. Well, that is not finished; I have got it in the rough, is all I can furnish you with a copy of that, though.

X Q. 9. I want to see the whole day's operations. As a matter of fact our representatives were there at half past ten, and from there on, although it is true the samples were not taken except during that period.

A. This covers the period that the samples were taken.

X Q. 10. I want the record for the whole day's run, and the day before and the day after, and I would like you to bring me the original data that are on record in your office.

A. All right.

X Q. 11. Now, these notes that have been put upon this—this first document here is a letter by you, and is your report to Mr. Bruce, the manager of that operation?

A. Yes, sir.

X Q. 12. And to that you append these sheets?

A. And there is a letter from the chief chemist and the oil chemist.

3913 X Q. 13. The chief chemist being R. B. Stringfield?

A. No; he is the oil chemist.

X Q. 14. Who is the chief chemist?

A. Edward Walser.

X Q. 15. And then there is this last letter to you; who is that signed by?

A. That is the head sampler?

X Q. 16. And his name is——?

A. T. R. Featherly.

Mr. Williams: It would seem that the regular procedure would be to call these men, but I am quite willing to take it prima facie in this form, and see if we can be satisfied with it.

The Court: Very well; they are available no doubt.

The Witness: I have some figures that you asked for the other day, Mr. Williams, in regard to the assay of the sulphate.

X Q. 17. The assay of the sulphate of copper that you purchased from the Anaconda Company?

A. No, just the amount of copper sulphate and sulphuric acid which we were using during the month of November, 1916. You also asked for the period of time that we used the reconstructed oil.

Mr. Scott: I offer the memorandum produced by the witness entitled "Butte & Superior Mining Company, Data Compiled from Original Record, Flotation Plant Operations, Month of November, 1916."

Table admitted marked Defendant's Exhibit No. 228.

3914 X Q. 18. Now, that other matter?

A. On November 17th reconstructed Barrett oil was used for 16 hours, and No. 2 pine oil for eight hours.

X Q. 19. And each used alone?

A. Each used alone, yes.

X Q. 20. In what proportion?

A. They were used separately. The reconstructed Barrett oil was used exclusively for a 16-hour period and the pine oil exclusively for eight hours.

X Q. 21. In what proportion per ton of ore?

A. Well, those sheets that I gave you show that; I don't remember off-hand. On November 18th the reconstructed Barrett oil was used for 18 hours and No. 2 pine oil for 16 hours.

X Q. 22. Have you described what reconstructed Barrett oil is, how it is made?

A. No, I have not. I don't know what this particular reconstructed Barrett oil was, but ordinarily we use about 95%.

X Q. 23. How is it made; what does reconstructed mean?

A. Well, it is just simply distilled or cooked for a period of three or four hours with sulphur.

X Q. 24. It is distilled under conditions so that the condensed part flows back?

A. Flows back, yes.

X Q. 25. In a reflex condenser?

A. Yes.

X Q. 26. That No. 2 pine oil, how is that differentiated from No. 1 pine oil?

3915 A. It is simply a marking that they have.

X Q. 27. A commercial name?

A. A commercial name, yes.

X Q. 28. Yaryan, is it?

A. Yes, I think it is; in fact I am sure it is.

Witness excused.

Mr. Scott: I understand that samples have been furnished to plaintiff's representatives of all of the oils mentioned in these various reports, and that being the case I would like to have the record so show.

Mr. Williams: Well, I don't know whether it is so or not. I can get reports.

Mr. Scott: Very well, I will have Mr. Dosenbach testify to it.

Mr. Williams: I think we got some nine samples yesterday, but I am not ready to say we have samples of everything. I will when I know it.

BEN H. DOSENBACH, recalled, testified as follows:

Direct examination.

By Mr. Scott:

Q. 213. Will you please state what oil samples you furnished to a representative of the plaintiff and to what representative you furnished them?

A. I furnished a sample of number 1 creosote, number 2 creosote, Yaryan pine oil, Barrett's number 4, Graybull fuel oil, Jones' crude oil, Graybull paraffin base oil kerosene and Yaryan
3916 mixed pine to representatives of the Minerals Separation Company, Mr. Higgins and Mr. Truran. These samples were requested of me to furnish.

Q. 214. They were samples of the actual materials used in the mill?

A. They were such as we use in the Butte & Superior Company's mill.

Q. 215. Were there any other samples of anything else furnished to them?

A. Yes, there have been samples furnished of every test that was made.

Q. 216. In court you mean?

A. In court.

Q. 217. Yes, but I mean the mill materials.

A. And samples were furnished Sunday of everything that was used, oils and acids and sulphates.

Q. 218. Sunday the 29th of April?

A. Yes, sir.

Cross-examination.

By Mr. Williams:

X Q. 219. Mr. Dosenbach, it appears that these pine oils are used separately, and you have given us a mixed sample?

A. I gave you two samples. The oil is contained in one tank,

which contains several pine oils and when we use from that tank up there consequently we can not use either one of them separately. We do not have the capacity to put one particular oil by itself so that one tank contains mixed pines; and a sample of this was
3917 furnished and also a sample of the standard pine was furnished.

X Q. 220. And that standard pine, has it any particular name? Is it number 1?

A. No, we call it "standard pine oil" because it has the greater specific gravity, and is somewhat purer than the other.

X Q. 221. Can you furnish a specimen of the number 2 separate, that you formerly mixed with the standard?

A. I think it may be possible from the stock bottles to furnish that.

X Q. 222. Will you do so?

A. I will, yes, be glad to.

Mr. Kremer: Mr. Williams, Mr. Chapman and Mr. Truran, whose names are mentioned, are your representatives, are they not?

Mr. Williams: Oh, yes, yes.

Witness excused.

Mr. Sheridan: If the court please, I have an understanding with counsel on the other side that we may introduce a printed transcript from the stenographer's record taken from the argument of both sides in the Supreme Court. We desire to enter a part of the argument which appears on page 85, Mr. Kenyon's admission. In reference to that he wants me to read into the record beginning on page 83 down to the bottom of page 85 and that I agreed to do. They will object to its competency.

3918 Mr. Garrison: No, we do not object to its competency. We object to its relevancy and materiality. We do not require them to produce any proof that the language contained on the pages of this book which are referred to is the language used by Mr. Kenyon or the language used by Justice McReynolds or by Justice Pitney, or whoever uttered the language. We will waive the competency of proof. We do say it is utterly irrelevant and immaterial.

Mr. Sheridan: We will read that so it will appear in the record and then offer the book as defendant's exhibit 228.

Mr. Garrison: By what procedure do they read it into the record before your honor has admitted it?

The Court: What are you offering?

Mr. Sheridan: We offer the part on page 83, page 84, and page 85. The reason of the materiality of it is this: First, it goes to show the definition these gentlemen have placed on their invention; and, secondly, they are alleging in this case that we are estopped by the Hyde former adjudication. Certainly anything that makes then in favor of Hyde in the former adjudication would make in favor of the defendant here; and any admissions made in solemn court such as they are, are undoubtedly of advantage to the court in any case in which he is a party. We have set it up as a defense, estoppel.

The Court: Well, there ought to be some law about that. I will allow it to go into the record, however.

3919 Mr. Garrison: Your honor does not care to hear me before the ruling?

The Court: No, it will be before—let's see, how many other courts? One court at least. The objection will be overruled and the matter will be admitted, the three pages, and if entitled to no consideration the court will give it none in making up its decision.

Pages in question admitted in evidence and marked Defendant's Exhibit 229.

Mr. Sheridan (Reading): "Washington, D. C., Tuesday, October 1, 1916.

"Argument of Mr. William Houston Kenyon in reply for Petitioners-Complainants.

"Mr. Kenyon: May it please the court, the question at issue, and the only question, is the question of invention. Did the step that our patentees took constitute invention? The court below said no; it was simply a matter of degree. Respondent's counsel here defends that proposition by saying that our result is attained not by the diminution in the amount of oil, but by some trick of agitation, some novelty of agitation. I will address myself first to that latter proposition.

"And the history of the birth of this invention is a complete answer to it. (Record pp. 446-448-451).

"If your honors have not already marked those pages in the record, I will ask you to mark them; the whole of page 448, the whole of page 451, and, on page 445, the paragraph just below the middle, commencing 'peripheral velocity of cone.'

3920 "Contemporaneous documentary records, written within a few weeks of the birth of this invention—evidence of an extraordinary character of the birth of a most extraordinary invention. These inventors were working on the Cattermole process—which, as has been explained, agglutinates by oil in about three per cent proportion the metal particles into bigger granules such that they sink against an upcurrent of water which carries the gangue up and away—the Cattermole process. They were experimenting with modifications of all the conditions of that process. Among them one line of investigation was as to the influence of changes of peripheral velocity. All sorts of variations, from 840 to 1,460, in the speed of the cone, were made, but the invention in issue was not born.

"Another line of investigation was as to the influence of changes in the amount of oil (page 447, the seventh item). Out of that series of experiments (where the only change made from experiment to experiment was in the amount of oil—a gradual diminution in the amount of oil, all other things remaining the same) was born this invention.

"And the record of it is right there on page 448, 'Details of Experiments,' the last column, 'Remarks,' 'Float vastly increased'—tracing that back you see it was with three-tenths of one per cent of oil; and just below 'Float' again 'vastly increased'—tracing that back it was with one-tenth of one per cent of oil.

"This float phenomenon appeared (page 451) when the oil had been reduced to about one-half of one per cent, said the in-
3921 ventors, after studying the process six weeks.

"As the amount of oil was reduced granulation practically ceased at a range of about one-half of one per cent of oil, but a certain amount of black mineral froth was noticed. They were trying to send the values down, but they began to come up to the top.

"Mr. Justice Day: Is that on page 451?

"Mr. Kenyon: Page 451, the third paragraph:

"'A certain amount of black mineral froth was, however, noticed as a result. On successively decreasing the amount of oleic acid below 0.5 per cent (that is one-half of one per cent) it was found that whereas granulation ceased there was a growth in the amount of mineral float-froth under these conditions, and that the production of such float-froth appeared to reach a maximum when about 0.1% of oleic acid on mineral was used.'

"If that evidence is true it disposes of the contention that this phenomenon which has revolutionized ore concentration the world over is to be explained as some trick of agitation.

"Mr. Justice Day: How do we know that fact, that it has revolutionized ore concentration the world over?

"Mr. Kenyon: How do we know it? This record shows that up to 1912 about $9,000,000 worth of values had been taken out, in Australia and Sweden and Chile, from dump heaps that had been valueless theretofore, by this process. The testimony that was taken in 1915 before Judge Bradford shows what had happened
3922 in the intervening three years, as pointed out in his opinion, during which three years an astounding development occurred in this country.

"Mr. Justice McReynolds: I would like to ask you when in this process of reducing oil your invention came into existence.

"Mr. Kenyon: At about one-half of one per cent of oil.

"Mr. Justice McReynolds: Before you got to one-half of one per cent did you have any invention?

"Mr. Kenyon: We were passing from the region of Cattermole, which was a distinct——

"Mr. Justice McReynolds: I want to know when your invention came into existence.

"Mr. Kenyon: This invention was not reached, I should say, from those figures, until about 0.5, that is, one-half of one per cent., of oil was reached.

"Mr. Justice McReynolds: At one per cent you had no invention?

"Mr. Kenyon: No.

"Mr. Justice McReynolds: At one-half of one per cent you did have invention?

"Mr. Kenyon: It began to come. Remote, but it began to come. At 0.3 of one per cent the float vastly increased. At 0.1 of one per cent the float again vastly increased.

"Mr. Justice McReynolds: When this float has more than one-half of one per cent it does not infringe?

"Mr. Kenyon: It does not infringe.

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